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MORPHOLOGY AND ONTOGENY OF THE SPERMOGONIA OF THE MELAMPSORACEAE

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With plates 182-188

THE MORPHOLOGY and the ontogeny of the spermogonia of rust fungi have thus far received relatively scant attention. Contributions of greater or less significance have been made by Unger (73), Meyer (59), Tulasne (72), DeBary (29, 30), Sappin-Trouffy (66), Blackman (19), Rosen (65), Neuman (60), Maire (55), Allen (3, 5, 6, 8), Ludwig (54), Hunter (45), Jackson (47, 48) and others; but they have been so incidental, fragmentary or introductory in nature that the subject still remains largely unexplored. It would seem that such topics must be of importance with respect to spermogonia just as they are of other reproductive organs, and especially to students of systematic uredinology. Motivated by this viewpoint I have studied the spermogonia of a wide range of species. The paper here presented records part of this work. It is restricted to the Melampsoraceae, and particularly to representatives of the various genera of the Melampsoraceae that occur in temperate North America and Europe.

The material of all *Melampsora* species discussed in this paper was obtained from culture experiments made by W. P. Fraser, J. H. Faull, H. P. Bell, E. H. Moss, G. D. Darker, E. H. Bensley, W. R. Watson and the writer, and from supplementary field material, except that no naturally occurring specimens of *Melampsora Larici-Canadensis* were available.

All of the cultured material, exclusive of that obtained from Professor Fraser, was fixed when in fresh condition. Treatment of the material was similar to that described by the writer (45), with the exception that fresh material of *Uredinopsis*, *Milesia* and *Melampsora* species was sectioned by hand and studied in an aqueous solution and after mounting in lacto-phenol. A combination differential staining method, using

safranin and light green in lacto-phenol, was introduced for material of *Milesia polypodophila* and *Coleosporium* species after embedding in celloidin. This method was devised without knowledge of Lepik's (52) method of double staining in lacto-phenol. The ethyl-butyl alcohol series was preferable to the ethyl alcohol series used previous to embedding.

The data obtained on each of the species dealt with here are presented in detail with reference to (1) morphology of mature spermogonia, (2) their ontogeny. This procedure has been adopted because of the fact that detailed descriptions of these organs by other authors have been meager at best, and most frequently are non-existent. The species selected belong to the following genera and subfamilies:

- I Subfamily MELAMPSOREAE — *Melampsora*
- II Subfamily PUCCINIASTREAE — *Melampsoridium*, *Melampso-*
rella, *Pucciniastrum*, *Thecopsora*, *Calyptospora*,
Hyalopsora, *Milesia* and *Uredinopsis*.
- III Subfamily CRONARTIEAE — *Cronartium*
- IV Subfamily CHRYSOMYXAE — *Chrysomyxa*
- V Subfamily COLEOSPORIEAE — *Coleosporium*

From this it will be seen that the only genera of the Melampsoraceae as recognized by Dietel under the family Melampsoraceae (Engler and Prantl's *Natürliche Pflanzenfamilien*, Band 6, 2nd ed. pp. 35-48, 1928) not included here are *Chnoopsora* and five genera the haploid stages of which are unknown — *Mesopsora*, *Phakopsora*, *Crossopsora*, *Mikronigeria* and *Bubakia*.

I. Subfamily MELAMPSOREAE

The Melampsoreae comprise three genera, namely, *Melampsora*, *Chnoopsora* and *Bubakia*. Three species of *Chnoopsora* are known; they occur in India and Central Africa; their spermogonia are said to be subepidermal; no material was available for study.

1. *Melampsora Abieti-Capraearum* Tubeuf

Arthur (16) considers *Melampsora Abieti-Capraearum* Tubeuf on *Abies alba* Mill. in Europe and *M. americana* Arthur on *A. balsamea* (L.) Mill. in America to be the same species. My studies on their spermogonia afford support to this conclusion.

The morphology of the spermogonia of the American rust has already been described by Hunter (45). Subsequent examination of additional specimens reveals no essentially divergent data. Quite recently my studies have been extended to the spermogonia of the European rust. The similarities of the American and the European materials

are so close that a summarized presentation of the data for both, as found in Table II below, will suffice. It should be noted, however, that in both of them certainty as to the location of mature spermogonia with reference to the epidermis is often impossible. Some are plainly subepidermal; others appear to be subcuticular. Here then is a case in which the correct description of the spermogonium requires a knowledge of its ontogeny. To clear up this point I have made a thorough study of the ontogeny of the spermogonia of this rust on *A. balsamea*, both from culture and field materials.

The spermogonial primordia in all cases examined lay immediately under and in contact with the epidermis. Usually it forms in an air space (commonly a substomatal cavity), but sometimes between the epidermis and the otherwise contiguous palisade tissue. The primordium consists essentially of closely adhering, vertical, actively growing hyphae, interpreted as spermatophores, with a suggestion at times of a thin, basal, hyphal mat. Figure 1 (drawn from a lateral, vertical section of a mature spermogonium) adequately illustrates a typical primordium and also initial stages of disruption of overlying epidermal cells. Subsequent developmental stages comprise a thickening of the basal mat (Fig. 2) accompanied by some destruction of underlying mesophyll, and a maturing of the spermatophores accompanied by a variable amount of destruction of overlying epidermal cells or none at all. These different effects on the epidermis, as revealed by serial sections, may occur within the limits of a single spermogonium.

Destructive action on the mesophyll is indicated in Fig. 3 by a break in the continuity of three layers of its tissues, and by the dark-staining remains of palisade cells embedded in the spermogonium. Among the epidermal cells the guard cells are the most resistant (Fig. 2). They may be invaded; but even so, their thick walls persist and the cells retain their contour. The effect on other epidermal cells is shown in Fig. 1, where it is seen that two hyphae are pushing inwards the lower wall of one cell, and others have already invaded the cell to the right the protoplasm of which is now dead. Almost all conditions of the epidermis overlying a mature spermogonium, as described above, are represented in Fig. 1 of Hunter (45).

The conclusion is that the spermogonium of *M. Abieti-Capraearum* is properly described as subepidermal, and not subcuticular as asserted by Ludwig (54). It consistently originates under the epidermis; and in the course of its development there is more or less destructive action of underlying tissues, and often of the epidermis even out close to the cuticle.

As an addendum it is of interest to note that a few sections showed long hyphae extending beyond the surface of the spermogonium. They were found centrally located in spermogonia that had just matured, never in old spermogonia. Spermatia were massed around them and, unlike paraphyses, they were ephemeral. These I interpret as the "flexuous hyphae" of Craigie (27).

2. **Caeoma Faulliana**, n. sp.

O, I.

Pycnidia amphigena, inconspicua, flavida, pustulata, non immersa, hemisphaerica vel conoidea, subcuticularia, 42–145 μ lata et 27–49 μ alta, plus minusve $80 \times 37 \mu$; pycnidiophora simplicia, non septata vel juxta bases septata, ad apicem dehiscentia, poris 12–15 \times 23–30 μ . Aecidia hypophylla, maculis flavidis insidentia, secus series duas irregulares disposita, aecidiosporis globosis vel subglobosis, subtilitèr verruculosus, 16–21 μ diam.

The material studied was collected by Mr. W. R. Watson on the needles of the current season of *Abies lasiocarpa* (Hook.) Nutt. at Banff, Alberta, July 8, 1925. It consisted of pieces fixed in Carnoy's fluid for study of the spermogonia and dried herbarium specimens (Herb. J. H. Faull, no. 8849). The spermogonia (Fig. 4) at once distinguish this rust from *M. Abieti-Capraearum* which it superficially resembles. They are smaller, more elevated (pustular) and plainly subcuticular. No doubt it is a species of *Melampsora*; but until someone makes appropriate cultures the identity of its diploid phase will remain unknown. So it is tentatively referred to as a new species under the name given above.

3. **Melampsora Abietis-canadensis** (Farl.) Ludwig

The spermogonia of *Melampsora Abietis-canadensis* are borne on leaves of the current season, young cones and young twigs of *Tsuga canadensis* (L.) Carr. The affected leaves, especially those of the terminal buds, may be distorted and Adams (1) states that the same is true for affected twigs. The spermogonia are abundant, small, subcuticular, amphigenous, pustulate, and hemispherical-flattened to conoidal in vertical section (Fig. 6). The base of the spermogonium is a flat-bottomed stroma. The epidermal cells at the base of the spermogonium are separated more or less by mycelium but they are not greatly displaced; they are eventually killed and may be disrupted, though frequently their walls remain unbroken. Thirty-four spermogonia occurring on needles measured from 35–98 μ broad and 15–38 μ high, averaging $66 \times 25 \mu$. On the cones seventy-seven spermogonia measured 53–128 μ broad and 13–30 μ high, averaging $78 \times 23 \mu$. The spermatia are discharged through a long slit, 8–30 μ wide. The foregoing description

is based upon culture material supplied by Professor W. P. Fraser.

Considerable confusion has existed in the past with respect to the identity of *M. Abietis-canadensis* on *Tsuga* (4, 37, 38, 39, 16, 68, 69), but the conclusion as expressed by Ludwig (54) and Arthur (16) is accepted. It is pertinent, however, to call particular attention to a rust (*Caeoma dubium* Ludwig, 54) on *Tsuga heterophylla* (Raf.) Sarg. from western North America. The spermogonia of this rust are distinguished from those of *M. Abietis-canadensis* as well as from other known species of *Melampsora*. The spermogonia of *C. dubium* are subepidermal and measure 80–115 μ broad and 50–90 μ high. This affords another example of the diagnostic value of spermogonia.

4. *Melampsora Bigelowii* Thüm.

The spermogonia of *Melampsora Bigelowii* are found on needles of *Larix laricina* (Du Roi) K. Koch and *L. leptolepis* Murr. They are small, abundant, usually discrete but sometimes confluent, pustulate, amphigenous, subcuticular, and hemispherical to conoidal in vertical sections (Fig. 7). The epidermal cells below the spermogonium, except for slight separation by the mycelium, are usually left *in situ*; but occasionally they are widely separated and sometimes so completely obliterated that the spermogonium occupies the space where the epidermal cells were located, as well as extending above them. Forty-two spermogonia measured 50–102 μ broad and 15–38 μ high, averaging $69 \times 27 \mu$. The spermatophores may be nonseptate or one-septate towards the base. The spermatia measure $1.5\text{--}2.0 \times 3\text{--}4 \mu$. The opening through which the spermatia are exuded is 15–30 μ wide and extends over the greater part of the spermogonium in the longitudinal direction of the leaf.

Both spermogonia and caemata were obtained on *Larix leptolepis* and *L. laricina* from inoculation experiments in which the teliospores of North American species of *Salix* were employed. The material on *L. laricina* only was sectioned.

5. *Melampsora Medusae* Thüm.

The spermogonia of *Melampsora Medusae* occur on needles of *Larix laricina* and *L. leptolepis*. They are indistinguishable from those of *M. Bigelowii*. Both spermogonia and caemata were obtained on *Larix leptolepis* and *L. laricina* from inoculation experiments in which teliospores from North American species of *Populus* (including *P. tremuloides*) were used. The material on *L. laricina* was sectioned.

6. *Melampsora Larici-Capraearum* Kleb.

The spermogonia of *Melampsora Larici-Capraearum* are borne on needles of *Larix laricina*. They are abundant, small, discrete or occa-

sionally confluent, pustulate, amphigenous, subcuticular and in vertical section conoidal to hemispherical (Fig. 9). The epidermis is somewhat depressed by the overlying spermogonium. Its cells are separated and sometimes killed by the hyphae which have passed through to form the basal stroma. Sometimes the area formerly occupied by these cells is filled with a mass of interwoven hyphae. Thirty-one spermogonia measured $30\text{--}101\ \mu$ broad and $18\text{--}38\ \mu$ high, averaging $65 \times 28\ \mu$. The spermatophores may be septate towards their bases. Usually they are single-celled but they may be bicellular and the cells are uninucleate. The spermatia are catenulately produced and they measure $1.5\text{--}2.8 \times 3\text{--}4\ \mu$. The pore through which the spermatia are exuded measures $7.5 \times 28.0\ \mu$ wide and may extend over the entire length of the spermogonium. Figure 8 represents an immature spermogonium. Here the cuticle may be seen stretched beyond the free ends of the spermatophores. This condition has been observed frequently.

Spermogonia and caemata were obtained on *Larix decidua* and *L. laricina* from the European rust in its telial stage on *Salix caprea*. The spermogonia on both species of *Larix* were studied.

II. Subfamily PUCCINIASTREAE

7. *Melampsoridium betulinum* (Pers.) Kleb.

The spermogonia of *Melampsoridium betulinum* occur on needles of *Larix decidua*. They are abundant, minute, amphigenous, subcuticular, pustulate and in vertical section hemispherical flattened to conoidal (Fig. 5). The epidermal cells may remain *in situ* or may be separated by mycelium. The spermogonia measured $45\text{--}53\ \mu$ broad and $12\text{--}15\ \mu$ high. The spermatophores arise from a stroma which forms over the epidermal cells. The opening through which the spermatia are emitted is a slit $8\text{--}11\ \mu$ wide. The spermogonium of *M. betulinum* is of the same type as that of *Pucciniastrum* species and of such species of *Melampsora* as *M. Bigelowii* and *M. Medusae*.

Arthur (15) reports the haploid stage on *Larix laricina* (Du Roi) Koch from Connecticut and Wisconsin. An examination of specimens from the materials on which the American records are based (supplied through the courtesy of Dr. G. P. Clinton) shows the rust is *Melampsora* sp. True, a few weak peridial cells are present in the aecia but nowhere is there any indication of a well-defined peridium. Since it is now known that fragile, evanescent peridia are present in certain *Melampsora* species, this may account for the confusion which has resulted in error in determination. So far then as verified records go, the haploid stage of *Melampsoridium betulinum* has yet to be found in North America.

In 1898 Klebahn (51) established the genus *Melampsoridium*. He successfully cultured the rust on *Larix* and identified the haploid stage (bearing typical peridermia) with the *Caeoma Laricis* of Plowright (63). The writer has cultured from the telial stage of *M. betulinum* (from *Betula verrucosa*) to *Larix decidua* and *L. laricina*, obtaining scanty infection of both spermogonia and aecia. The latter are true peridermia.

8. **Melampsorella Cerastii** (Pers.) Schroet.

A description of the morphology and of the ontogeny of the spermogonium of *Melampsorella Cerastii* is already recorded by the writer (45) under the name *Melampsorella Caryophyllacearum*. Figure 10 adds an excellent photographic illustration.

9. **Pucciniastrum Epilobii** (Pers.) Otth.

10. **Pucciniastrum Abieti-Chamaenerii** Kleb.

The spermogonia of one of these species, the identity of which was unknown at the time, has already been described by the writer (45) under the name *P. Epilobii*. Subsequently, authentic culture materials of both were made available through the courtesy of Professor Faull, and their spermogonia have been studied in detail. No constant differences were evident. Professor Faull, however, pointed out that there are specific differences in the aecia of the two species, and my examination of his herbarium specimens leads me to the same conclusion.

11. **Pucciniastrum americanum** (Farl.) Arth.

The spermogonia of *Pucciniastrum americanum* occur on leaves of the current season of *Picea glauca* (Moench) Voss. They are small, discrete, amphigenous, irregularly scattered, subcuticular, pustulate, and in vertical section hemispherical flattened in shape. The epidermal cells at the base of the spermogonium are separated by hyphae passing between them into the spermogonium. As the rust nears maturity these cells are somewhat depressed and frequently die; but there is no great disruption of host tissue. Twenty-nine spermogonia were found to measure 71–185 μ broad and 18–62 μ high, averaging $124 \times 35 \mu$.

The spermatophores are usually either nonseptate or one- to two-septate in the lower third of their length. They branch, just as do those of *P. arcticum* (Fig. 13), from enlarged basal hyphae. The spermatia form catenulately and they measure $1.5 \times 3.5 \mu$ in my sections. Measurements of spermatia from fresh material according to Darker (28) are $2.0\text{--}2.4 \times 3.9\text{--}5.9 \mu$. Frequently the opening through which the spermatia emerge measures 7.5–45.0 μ broad and extends as a slit over the greater part of the spermogonium. The cuticle may curl back exposing a considerable area of the upper surface of the spermogonium. At ma-

turity "flexuous hyphae" have been found extending beyond the tips of the spermatophores through the opening of the spermogonium.

12. ***Pucciniastrum arcticum*** (Lagerh.) Tranz.

The spermogonia of *Pucciniastrum arcticum* occur on first year needles of *Picea glauca* and resemble those of *Pucciniastrum americanum* so closely that it is probably impossible to separate them on a morphological basis (Fig. 12). It should be noted, however, that the spermatophores of *P. arcticum* are commonly one-septate near their bases (Fig. 13). The spermatia, too, are possibly distinctive. In prepared sections they were found to measure $1.5\text{--}3.0 \times 4.5\text{--}6.0 \mu$. Darker's measurements (28) made from fresh material were $1.3\text{--}1.6 \times 3.9\text{--}4.7 \mu$.

13. ***Thecopsora minima*** (Schw.) Syd.

The spermogonia of *Thecopsora minima* are borne on the leaves and young cones of *Tsuga canadensis*. Spermogonia on the leaves only were examined by the writer. They are small, usually discrete but occasionally confluent, amphigenous, irregularly scattered over the leaf surface, subcuticular, pustulate and in vertical section conoidal to hemispherical flattened. Thirty-four spermogonia measured $38\text{--}120 \mu$ broad and $15\text{--}25 \mu$ high, averaging $79 \times 20 \mu$. The opening through which the spermatia are exuded measures $14\text{--}15 \mu$ wide and extends as a slit over the spermogonium for most of its length. The materials studied were obtained from Professor W. P. Fraser. He secured them by inoculating *Tsuga canadensis* with basidiospores from *Rhodora canadensis*.

A difference of opinion exists (37, 16, 38, 39, 64, 1, 70) as to whether or not *T. minima* and *T. Myrtilli* are distinct species. It is doubtful if the spermogonial characters afford any aid in answering this question. It should be added that in all of the experimental work carried on in connection with *Thecopsora minima* and *T. Myrtilli* the infection experiments necessary to prove that the uredial stage on the various telial hosts *Vaccinium*, *Gaylussacia*, *Rhodora* and *Azalea* have never been performed. Gross inoculations with urediospores from one diploid host plant to the other would be of some value; but the experiments should be carried on by inoculating from the telial stages on various hosts to *Tsuga*, and when the aecia are secured inoculations should be made from each source back to all the various telial hosts. It would be well to include *Thecopsora Hydrangeae* in such a set of experiments.

14. ***Thecopsora Myrtilli*** (Schum.), n. comb.

Aecidium ? *Myrtilli* Schum.

My study of the spermogonia of *Thecopsora Myrtilli* is based on culture material obtained by Fraser (38) as the result of inoculations from

Vaccinium canadense Kalm on to *Tsuga canadensis* (L.) Carr. No significant differences were found between those of *T. Myrtilli* (Fig. 14) and *T. minima*.

15. **Thecopsoara Hydrangeae** (B. & C.) Magn.

The spermogonia of *Thecopsoara Hydrangeae* are borne on first year needles of *Tsuga canadensis*. They are small, usually discrete but sometimes confluent, amphigenous, subcuticular, pustulate and in vertical section hemispherical flattened to low conoidal. The stroma of the spermogonium does not usually depress the underlying epidermal cells. Thirty-five spermogonia measured 75–126 μ broad and 15–26 μ high, averaging $99 \times 24 \mu$. The aperture through which the spermatia are discharged is a slit 15–23 μ wide.

16. **Calyptospora Goeppertiana** Kühn

Since an earlier study of the spermogonia of this rust was made by the writer (45) examination of another lot of cultured material confirms the fact that spermatia do not ordinarily form and that the cuticle above the spermogonium remains unbroken. More than five hundred spermogonia have been examined. In these, spermatia were never found to have emerged. In many of the sections mature aecia were present. Frequently the spermogonia are dwarfed. Occasionally growth proceeds little further than is shown in Fig. 11.

17. **Hyalopsora Aspidiotus** (Pk.) P. Magn.

The morphology of the spermogonia of *Hyalopsora Aspidiotus* has already been adequately described (45) and due reference made to Mayor's findings in European material (57). Recently Kamei (50) has described similar but apparently somewhat bulkier spermogonia of his new species *H. aculeata*, cultured by him from *Blechnum Spicant* var. *nipponicum* (K.) M. & K. to *Abies Mayriana* Miy. & Kudo. In continuation of my studies on *H. Aspidiotus* on *Abies balsamea* I am now able to present for the first time an account of the ontogeny of its spermogonia.

The young spermogonium arises subepidermally from a very loosely scattered web of mycelium in the outer intercellular spaces of the mesophyll (Fig. 16). At a very early stage in its development, hyphae (potential spermatophores) branch off anticlinally from this web; and very soon they come to form a continuous layer directly under the epidermis. During the latter process the intervening mesophyll cells are loosened from their connection with the epidermis and they and their neighbors in the outer layer of mesophyll are pressed downward into the spaces below. Frequently a number of the mesophyll cells become in-

volved in the growth of the spermatophores. They are surrounded and eventually disrupted (Fig. 15). At maturity the epidermal cells above the spermogonium are usually killed; occasionally their walls are broken down by the mycelium (Fig. 16); and at times they may be penetrated by haustoria (Fig. 16). During the formation of the spermogonium the host leaf tissue becomes much swollen (Fig. 15) and drops of tannin and resinous matters form in affected cells — the former being especially abundant in the immediate neighborhood of the spermogonium. Within this region, too, starch grains fill the cells in abnormal amounts.

18. *Milesia intermedia* Faull

In an earlier paper the mature spermogonium of *Milesia intermedia* on *Abies balsamea* was described by the writer (45) under the name *Milesina Kriegeriana* Magnus. Faull (35) has recently shown that the latter is a different species and that it is not known to occur in America. The spermogonia of *M. intermedia*, just as is true of other known Milesian spermogonia, are depressed in the host tissues at maturity. But an examination of mature spermogonia of *M. intermedia*, just as with most species of *Milesia*, leaves one in doubt as to their relation to the epidermis, that is, as to whether they are subepidermal, intraepidermal or subcuticular. To arrive at the correct interpretation in such species ontogenetic studies are necessary. These have been made for several of them by the writer. An account of the ontogeny of the spermogonium of *M. intermedia* follows. It plainly is of subcuticular origin.

The spermogonium of *Milesia intermedia* (Fig. 17) originates in the outer epidermal wall. Hyphae separate the granular layer underlying the cuticle from the wall strata below and growth of the young spermogonium continues in that region. As growth progresses the cuticular and granular strata are elevated and the underlying epidermal cells are depressed.

The formation of the pore in the cuticle, through which later the spermatia are exuded, is of interest. A spermogonium about half developed is shown in Fig. 18. At a central point above the row of spermatophores, the granular stratum which normally occurs immediately below the cuticle has disappeared. It is at this point that the cuticle breaks, the rupture being caused by pressure exerted by lateral growth of the fungus, and also by the filling of the cavity in the spermogonium with spermatia and spermatial fluid.

At this intermediate stage (Fig. 18) in the growth of the spermogonium the spermatia are well developed. The spermatophores are fewer and much more separated than in the mature stage. The growth of the spermatophores is from the stroma. They increase in number by

branching from the cells of the stroma. As the spermatophores multiply the underlying epidermal cells are pressed more deeply into the host tissue and some of them completely disintegrate.

The mature spermogonium, which, in an early phase was raised and lenticular, is approximately plane with the leaf surface on its outer facies. Its body is hemispherical and deeply immersed as the result of prolific basal growth.

19. *Milesia fructuosa* Faull

Milesia fructuosa was produced in Faull's (36) cultures on various species of *Abies* (Table I), and always on leaves of the first season. In these experiments the rust developed scantily on *A. nephrolepis* Maxim., *A. amabilis* (Dougl.) Forbes and *A. balsamea* and sometimes only spermogonia were borne; on *A. concolor* Lindl. & Gord. the rust was more abundant; but on *A. magnifica* Murr., *A. Fraseri* (Pursh) Lindl. and *A. Fraseri prostrata* Rehd. it was not only abundant but it distorted the leaves of the host. The distorting effect was very marked on *A. magnifica*. The writer studied the spermogonia obtained in these cultures; the results are recorded in Table I.

TABLE I.

Fir host	Number of spermogonia measured	Range in size Breadth \times Height in μ	Average size Breadth \times Height in μ	Remarks
<i>A. amabilis</i>	8	100-180 \times 68-84	134 \times 70	Mostly hypophyllous
<i>A. balsamea</i>	17	112-140 \times 76-96	137 \times 81	Mostly hypophyllous
<i>A. cephalonica</i>	—	Dead areas only	—	
<i>A. concolor</i>	32	80-160 \times 52-92	121 \times 67	Mostly hypophyllous
<i>A. Fraseri</i>	64	72-152 \times 40-100	117 \times 76	Mostly hypophyllous
<i>A. Fraseri prostrata</i>	68	88-144 \times 40-100	116 \times 68	Mostly hypophyllous
<i>A. magnifica</i>	198	80-172 \times 48-96	121 \times 60	Amphigenous
<i>A. nephrolepis</i>	6	108-180 \times 40-80	132 \times 66	Mostly hypophyllous

It will be noted that the measurements for the spermogonia of *M. fructuosa* vary somewhat from those given for *M. intermedia*; yet, if the mean or average measurements of the former are considered, they closely approach those given for the latter. Partly for this reason Faull (36) is inclined to regard these two as the same species (*M. fructuosa*). Certainly their spermogonia are, in general, similar in form and measure-

ments; and both are of subcuticular origin. The greatest aberration was found on *Abies magnifica* — on that host three percent of the spermogonia proved to be subpustulate.

20. *Milesia marginalis* Faull & Watson

The spermogonia of *Milesia marginalis* have been described by Hunter (45), Faull (35) and Arthur (16) as being subcuticular; and that is what mature spermogonia, with very rare exceptions, appear to be. But a study of their ontogeny shows that they originate subepidermally; and then, as development proceeds, by partially breaking down the covering epidermal cells from below, they come to lie in a subcuticular position much as though they had originated directly under the cuticle. Stages shown in this interesting sequence are represented in Figs. 19–21; and the condition at maturity is illustrated in Fig. 23 of this paper and Fig. 10 of an earlier paper by the writer (45).

Figure 19 portrays a spermogonial primordium — a thin mat of hyphae that is separating the epidermis from the underlying layer of mesophyll cells. On its outer facies it has projected haustoria into the epidermal cells and has already begun disintegration of epidermal cellular contents and lower cell walls. Indeed, hyphae now completely occupy a median epidermal cell shown and press against the inner face of its outer wall. The central part of the pad has forced the underlying mesophyll cells downward — the beginning of a process that terminates in a deeply depressed type of spermogonium.

Figure 20 represents a later stage, but a still very young condition of a spermogonium. The spermatophoric layer is now clearly defined; destructive action from below outwards on the epidermis is proceeding apace; and the depression of the spermogonium into the mesophyll is much more marked.

Figure 21 is drawn from a more advanced stage of an immature spermogonium. All that now remains of the overlying epidermal cells are the cuticle, outer strata of the superior walls and tooth-like portions based on them of the anticlinal partitions. Depression of the basal stroma is continuing, but the final hemispheric form has not yet been attained. Perhaps the most striking new feature is the space now lying between the spermatophoric layer and the reduced epidermal covering. This is the beginning of a hemispherical, fluid-filled cavity seen in a typical mature spermogonium. As yet spermatia are not forming but migrations of nuclei into the tips of a few of the spermatophores and appearances of subterminal constrictions indicate that the first spermatia are being organized.

Figure 23 (cf. Hunter, 45) is a good photomicrograph of a section

through a mature spermogonium. Spermatia are being produced abundantly and the central space is doubtless filled with spermatial fluid. The position of the slit through which the spermatia are discharged is evident. It is of particular interest to note that the epidermal membrane consists of the cuticle and a dark-staining layer (the middle of the outer epidermal wall). On the latter are based projections representing middle lamellar substance of the anticlinal partitions.

In conclusion two observations are worthy of record. (1) Very occasionally the overlying epidermis may remain partially (Fig. 22) or wholly intact. (2) A central core of hyphae much longer than spermatiphores has been seen in spermogonia that have reached about three-quarters of their full size. These are interpreted as being "flexuous hyphae," that is, hyphae which possibly are receptive organs with respect to the phenomenon of fertilization.

21. *Milesia polypodophila* (Bell) Faull

The morphology of the spermogonium of *Milesia polypodophila* (Fig. 26) has already been described by Hunter (45). Its ontogeny has not been studied, but note should be made of the fact that "flexuous hyphae" are present at the time the spermogonium has matured (Fig. 24).

22. *Milesia Blechni* (Syd.) Arthur

The spermogonia of *Milesia Blechni* occur on leaves of the current season of *Abies alba* (Fig. 30) and *A. cephalonica* Loud. They are amphigenous but usually hypophyllous, immersed and more or less flask-shaped in vertical sectional view. Nine spermogonia measured 110–175 μ broad and 105–150 μ high. In the absence of ontogenetical studies it is not possible to decide definitely whether they are of subcuticular or subepidermal origin.

23. *Milesia Kriegeriana* (Magnus) Arthur

The spermogonia of *Milesia Kriegeriana* are borne on leaves of the current season of *Abies alba*, *A. concolor* and *A. grandis* Lindl. They are inconspicuous, colorless, abundant, amphigenous, irregularly scattered, subcuticular, immersed, extending well into the mesophyll and hemispherical in sectional view (Fig. 31). No discoloration of the leaf or presence of any lesion can be detected with a hand lens until the spermogonia reach maturity, that is, at the time the spermatial fluid begins to be exuded. Then the affected areas become slightly lighter in color and of a pale yellowish tint. Sixteen spermogonia measured 98–168 μ broad and 94–168 μ high, averaging $129 \times 126 \mu$. The spermatiphores are septate at a distance of about one-third of their length from the base of the spermogonium. They are rarely two-septate. The

cells are uninucleate. The spermatia are catenulate, hyaline and narrowly cylindrical, measuring $1.5-2.0 \times 3.5-5.0 \mu$. They are exuded through a slit-like pore measuring $7.5-15.0 \times 25-80 \mu$. It should be added that while the spermogonia of *M. Kriegeriana* on *A. alba* and *A. grandis* are identical, those on *A. concolor* are shallower on the average.

Mayor (58) describes the spermogonia of *M. Kriegeriana* on *A. alba* as small, rounded, immersed in the tissues and $34-42 \mu$ in diameter — a description so different from that of the writer's that the question arises as to the identity of Mayor's materials.

My studies on the ontogeny of the spermogonia of *M. Kriegeriana* demonstrate their subcuticular origin. Previous to the formation of the young spermogonium, hyphae separate the epidermal cells laterally and then extend periclinally within the outer walls of the epidermal cells. The lateral extensions lie in a plane just below the intermediate wall stratum. Before long the epidermal cells appear to be surrounded by mycelium. The primordial stroma of the spermogonium originates, however, from the layer of mycelium in the outer epidermal wall. Young spermatophores are formed anticlinally on this stroma. The cuticle is raised above the surrounding leaf surface as in *M. intermedia*. After this stage is reached, basal growth of the spermogonium takes place rapidly. The epidermal cells are depressed and eventually disrupted. The basal stroma expands, the spermatophores increase in number and the spermogonium as a whole begins to take on a hemispherical form. These processes, accompanied by flattening or destruction of contiguous mesophyll cells, continue until maturity is reached. The eventual form of the spermogonium is very similar to that of *M. intermedia*.

24. *Milesia Polypodii* White

The spermogonia of *Milesia Polypodii* are borne on leaves of the current season of *Abies alba* and *A. concolor*. They are inconspicuous, abundant, amphigenous, subcuticular, colorless, immersed in the mesophyll, in vertical section hemispherical to slightly flask-shaped. No lesion or discoloration of the leaf is present until very shortly before the spermogonia open; then the affected areas become slightly lighter in color and of a pale yellowish tint. Thirty-four spermogonia measured $120-228 \mu$ broad and $105-194 \mu$ high, averaging $177 \times 162 \mu$. They are usually broader than high. The spermatophores are frequently septate at about one-third of their length from the basal stroma. They may be non-septate or two-septate. The spermatia are narrowly cylindrical, hyaline, catenulate, and measure $1.5-2.0 \times 4-5 \mu$.

Although many of the spermogonia on *Abies concolor* were deeply immersed and reached a size almost as great as those on *A. alba*,

nevertheless, they were frequently found to be raised somewhat above the surrounding epidermis and in such instances were much shallower than the immersed type on *A. alba*. *Milesia Polypodii* on *A. concolor* caused much distortion of the leaves, whereas on *A. alba* there was no noticeable distortion except that the leaf was distended where spermogonia were present. In both hosts the mesophyll cells of the region in which they occur are destroyed in the course of development.

The ontogeny of the spermogonia of *M. Polypodii* was studied from culture materials on *Abies concolor* and *A. alba*. They form essentially in the same way as those of *M. Kriegeriana*. Swollen hyphae separate the mesophyll cells immediately underlying the epidermal cells, and these are also separated laterally from one another by strands of mycelium. Eventually a mat of hyphae, by growth in a periclinal direction, cleaves the outer epidermal cell walls, thus coming to lie just below the layer that consists of the cuticle and the granular stratum. It is mainly from the mat developed in this location that the spermogonium originates. On the upper facies of the mat spermatophores grow out towards the cuticular covering and the isolated epidermal cells are irregularly distributed near its base. This stage is illustrated in Fig. 25, taken from a spermogonium about one-third grown. When the spermogonium has reached from one-half to two-thirds of its mature size (Fig. 32) a very interesting morphological phenomenon is to be observed. The spermatophores, not yet fully grown and not sporulating, are present in a semi-circular ring; while much longer, broader, non-tapering, non-septate, uninucleate hyphae, apparently rising from the same stroma as the spermatophores, form a central core. The spermatophores stain very deeply in contrast with the hyphae of this core. At an earlier stage in development than that just described, the central core of hyphae may be in contact with the overlying membrane of the host; but it soon becomes separated and when the "slit" is formed the hyphae of the core emerge and grow out 20 μ or more beyond the covering of the spermogonium. Sections of nearly mature spermogonia in which the spermatia have formed, but in which the cuticle is not yet ruptured, show that the spermatia have no particular tendency to cling to the long hyphae; but once the spermogonium has ruptured and there has been opportunity for contact with spermatia from other spermogonia the long hyphae may be found with spermatia attached. The dark band lying over the spermogonium shown in Fig. 33 is made up of spermatia apparently massed around the long hyphae. Occasionally a hypha is seen protruding from among the exuded spermatia and sometimes one can be recognized when cut transversely in section. Just what these long

hyphae are is not certain, but according to my interpretation they are "flexuous hyphae" as described by Craigie (27) for certain Pucciniaceae.

25. *Milesia Scolopendrii* (Fuckel) Arthur

The spermogonia of *Milesia Scolopendrii* are borne on leaves of the current season of *Abies alba* and *A. concolor*. They are inconspicuous, amphigenous, apparently subcuticular, colorless, immersed in the mesophyll, in vertical section conspicuous and hemispherical to slightly flask-shaped. Twenty-eight spermogonia measured 120–228 μ broad and 100–188 μ high, averaging $156 \times 140 \mu$. These measurements are within close range of those given for *M. Polypodii* and it is difficult to distinguish these rusts by their spermogonia. The spermatophores are usually one- or two-septate near their bases; but occasionally they are entire. The spermatia are catenulate, hyaline, narrowly cylindrical, $1.5\text{--}2.0 \times 4\text{--}5 \mu$. The opening through which they are exuded measures $5\text{--}38 \times 40\text{--}110 \mu$.

No early stages in the development of the spermogonia were studied. But interesting observations were made on "flexuous hyphae" in mature or submature spermogonia. Spermogonia, twenty-seven to thirty days following inoculation on *Abies alba* and from which spermatia were just beginning to discharge, contained unusually long "flexuous hyphae" protruding far beyond the apical "slit." Hand sections of fresh material were made, then mounted in water, and finally preserved in lactophenol tinted lightly with acid fuchsin stain. Some of the "flexuous hyphae" in these sections were turgid and filled with cytoplasm, while others appeared empty and flaccid. One section was of especial interest (Figs. 28, 29). In it the spermatophores were of normal length and spermatia were present; but standing out in the central cavity there was a long flexuous hypha with spermatia attached, extending slightly beyond the aperture and about 105 μ beyond the tips of the spermatophores (Fig. 27). Another hypha was present to which spermatia were also attached, and these, as in the former instance, had remained adherent throughout the processes of washing and staining. In this same section there were at least six other "flexuous hyphae" in various conditions of turgidity or flaccidity. It may be added that "flexuous hyphae" were never found in old spermogonia. While the writer is not prepared to venture an opinion on the part played, if any, by "flexuous hyphae" in the sexual phenomena of rusts, yet, in continuation of such studies as have been made on this topic by Craigie (24–27), Pierson (62), Andrus (10) and Allen (7–9) it is suggested that species of *Milesia* would appear to afford excellent material. Their spermogonia are relatively large, they lack confusing paraphyses and they produce striking "flexuous hyphae."

26. *Milesia vogesiaca* (Sydow) Faull

The spermogonia of *Milesia vogesiaca* (Fig. 34) occur on leaves of the current season of *Abies alba*. They are inconspicuous, very abundant, amphigenous but mostly epiphyllous, apparently subcuticular, plane on the upper surface, deeply immersed in the mesophyll, and in vertical section spherical to slightly flask-shaped. Thirty-four spermogonia measured 154–241 μ broad and 168–214 μ high, averaging $201 \times 195 \mu$. The spermatophores branch from enlarged hyphal cells of the stroma which forms the base of the spermogonium. They are usually one-septate towards their bases but they may be two-septate, the second septum being about one-third of the length of the spermatophore from its base. The spermatia are narrowly cylindrical, hyaline, $1.5\text{--}2.0 \times 4\text{--}5 \mu$. The opening through which they are exuded is a slit-like pore in the cuticle, $5\text{--}35 \times 30\text{--}70 \mu$. "Flexuous hyphae," 6–9 μ in diameter, occur in mature or submature spermogonia.

The spermogonia of *M. vogesiaca* are much larger than those of any of the other European species of *Milesia*. They more nearly approach those of *M. polypodophila* in size, although the latter are generally larger. The spermogonia of *M. polypodophila* are subspherical, being elongated slightly along the vertical axis; while those of *M. vogesiaca*, also subspherical, are most frequently slightly elongated along the horizontal axis. Moreover, the spermogonia of *M. polypodophila* are distinctly subepidermal and also differ from those of *M. vogesiaca* in their much longer incubation period. Confusion as to the position of the latter in the host may result because the subcuticular area above the spermogonium is so narrow that in a lateral section there is an appearance of being subepidermal. Ontogenetic studies alone can determine whether or not the spermogonia are really of subcuticular origin.

27. *Peridermium rugosum* H. S. Jackson

The morphology of *Peridermium rugosum* was described by the author in an earlier paper (45).

28. *Uredinopsis mirabilis* (Peck) Magnus

The spermogonia of *Uredinopsis mirabilis* occur in *Abies balsamea* on leaves of the current season. They are inconspicuous, rarely confluent, hypophyllous, subcuticular, colorless, immersed in the mesophyll, in vertical section hemispherical and either quite flat on top, slightly raised above the surrounding epidermis or, in late maturity, centrally depressed. Forty-nine spermogonia measured 58–123 μ broad and 35–54 μ high, averaging $89 \times 44 \mu$. The same condition which exists in *Milesia intermedia* is found in *U. mirabilis*, namely, the combined cuticle and

the intermediate wall layer remain over the spermogonium at maturity. The spermatophores are one-septate, or occasionally two-septate, towards their bases. The basal cells are long and tubular, narrowing toward their upper ends. Formerly (45) this was thought to be an aid in distinguishing *Uredinopsis* species from *Milesia* species; but equally large basal tubular cells have since been found in the spermatophores of *Milesia* species. The spermatia are oval, hyaline, catenulate and measure $1.5-2.0 \times 3.5-4.2 \mu$. The opening in the cuticle through which they are exuded is a pore or short slit, $4-9 \times 10-40 \mu$.

Doubt has existed as to whether the spermogonia of this and various other species of *Uredinopsis* are subcuticular or subepidermal. Thus Arthur (15), in referring to the mature spermogonia of *Uredinopsis*, speaks of them as "extending between and depressing the tissues beneath, giving the appearance of being subepidermal." Indeed, it seems from the mature spermogonia as if this might be the case; but investigations of the earlier phases of their development in *U. mirabilis* show them to arise in a subcuticular fashion. After a certain amount of growth, the haploid mycelium begins to be directed towards the leaf surface and passes between the cells, along the middle lamellae, occasionally completely separating the epidermal cells from one another. Then the hyphae grow laterally and separate the outer epidermal wall into two layers. There is an interweaving of these hyphae and a stroma is organized; simultaneously, branches of mycelium from the stroma are sent out anticlinally and gradually the cuticle is raised. At the same time the underlying epidermal cells are slightly depressed due to pressure from the growth of the developing spermogonium. Figure 35 is an illustration of an early stage in the development of the spermogonium. It shows that the epidermal cells at the base have been separated and at least partly surrounded by the mycelium.

Although in its very early stages the spermogonium is superficial and raised above the epidermis, it later becomes immersed in the leaf tissue. The young spermatophores increase in number and lengthen. The epidermal cells gradually become crushed and finally they may disappear entirely. Usually the mesophyll cells immediately underlying the spermogonium are pushed downward into the leaf, probably filling up an intercellular space; occasionally they may be involved in the growth of the stroma and disappear. As the spermogonium becomes immersed the overlying cuticle resumes its former position and is more or less on a level with that covering the surrounding epidermis.

29. *Uredinopsis Atkinsonii* Magn. (Fig. 36)

30. *Uredinopsis Osmundae* Magn.

31. *Uredinopsis Phegopteridis* Arthur32. *Uredinopsis Struthiopteridis* Störmer

The spermogonia of all the four preceding species except *Uredinopsis Struthiopteridis*, have already been described by the writer (45). All resemble those of *U. mirabilis* so closely that these species cannot be distinguished from one another by their spermogonia. A recapitulation of their morphological data is found in Table II.

33. *Uredinopsis Pteridis* D. & H.

Little can be added to the account of the spermogonia of *Uredinopsis Pteridis* already given by Hunter (45) except to say that the literature on *U. Pteridis* and *Peridermium pseudo-balsameum* Arthur and Kern is a maze of confusion (cf. Schmitz, 67; Weir and Hubert, 74; Rhodes, Hedgcock, Bethel and Hartley, 64; Hunter, 45; Kamei, 49).

34. *Peridermium balsameum* Peck

Peck (61) discovered a white-spored rust on the leaves of *Abies balsamea* Mill., which in 1875 he named *Peridermium balsameum*. For many years, as pointed out by Faull (34), this name has been applied to the aecial stage of various North American species of the two genera *Milesia* and *Uredinopsis*. Fraser (38) was the first to demonstrate that five species of *Uredinopsis*, namely, *U. Struthiopteridis*, *U. Osmundae*, *U. Atkinsonii*, *U. Phegopteridis*, and *U. mirabilis* have their aecial stage on *Abies balsamea*. He considered that the peridermia of all of these would pass current for the *P. balsameum* of Peck. The occurrence of these five species on *Abies* was later confirmed by culture experiments carried out under the direction of Professor Faull (34). The Sydows (70) in referring to Fraser's work stated that the peridermia of the various North American species of *Uredinopsis* recorded in their Monographia cannot be distinguished from Peck's *P. balsameum* but they cite *P. balsameum* as a synonym of *U. Struthiopteridis* only. Arthur (15) chose to refer *P. balsameum* to *U. mirabilis*; but he also stated that the aecial stages of *U. Osmundae* and *U. Copelandi* Sydow are similar to those of *U. mirabilis*. Arthur and Kern (17) redescribed *P. balsameum* Peck. Their material comprised numerous specimens, including what they considered Peck's type material from the Adirondack Mts. and without realizing that in it more than one species was involved. Incidentally they ventured the opinion that *Aecidium pseudocolumnare* Kühn, as maintained by Farlow, might be identical with *P. balsameum*.

Faull (34) discovered that three American species of the genus *Milesia* on *Abies balsamea*, as well as those of *Uredinopsis*, occur on the leaves of *Abies balsamea*. Of these, *M. polypodophila* (Bell) Faull,

easily distinguished from the others by the occurrence on leaves 3-8 years old and by its strikingly distinctive morphological characters, apparently had been overlooked by collectors; but the remaining species referred to by him and occurring on leaves of the current season (as do those of the *Uredinopsis* species mentioned), had no doubt passed under the name *P. balsameum*.

It is now known that the genera *Milesia* and *Uredinopsis* in North America, as they occur on *Abies*, can be distinguished from one another by their spermogonia, and that similarly the species *Milesia intermedia* (perhaps more properly named *M. fructuosa* Faull), *M. marginalis* and *M. polypodophila* possess specifically distinctive spermogonia (45). Hence it is now possible to more exactly determine the identity of what Peck himself preserved in his herbarium under the name *Peridermium balsameum*. With this object in view the writer has critically examined Peck's collections stored in the Herbarium of the New York State Museum at Albany, N. Y. and made available through the courtesy of Dr. H. D. House.

The writer found two sheets of exposed specimens and two packets, all ascribed to Professor Peck as collector. There are various later collections in the Herbarium but these are not of pertinent interest here. The first sheet, regarded as the oldest (dating back possibly to 1873), carries several exposed specimens and bears the label, "*Peridermium balsameum* Peck, Adirondack Mts., New York State, July and Aug." Presumably it is the type sheet, though neither it nor any other is so marked. The specimens on this sheet prove to be predominantly *Milesia intermedia*; but one of them is a species of *Uredinopsis*. The second sheet, with several specimens mounted similarly to the first, bears the label, "*Peridermium balsameum* Peck, Charlotteville Swamp, N. Y. State, Aug." It is *M. intermedia*. The third collection was made at N. Elba, N. Y. State, in Aug. 1910, according to the label; it is also *M. intermedia*. The fourth collection is recorded as from L. Avalanche, Adirondacks, N. Y., dated Aug.; but as with the first two sheets, no mention is made of the year. It is a species of *Uredinopsis*.

The writer's conclusions are: (1) Peck's own collections of white-spored peridermial rusts on *Abies* comprised species of both *Milesia* and *Uredinopsis*, and were designated by him as *Peridermium balsameum*; (2) *P. balsameum* cannot accurately be designated as a synonym of any particular species of *Uredinopsis*, as has been done by Sydow and Arthur; (3) what is possibly the type sheet of Peck's *P. balsameum* carries a large proportion of *Milesia intermedia* but some material of an undeterminable species of *Uredinopsis*.

In the study of these plants serial sections were made of selected leaves, and comparisons were made with similar preparations from authentic materials (obtained from controlled cultures) of the various species of *Milesia* and *Uredinopsis* mentioned above, made available through the kindness of Professor Faull.

35. *Aecidium pseudocolumnare* Kühn

The first collections of *Aecidium pseudocolumnare* were made by Kühn in the Black Forest, Germany, in August and September, 1883. The spermogonia were not described but a detailed description of the aecia and aeciospores was given on labels attached to herbarium specimens. The aeciospores were said to be white, finely warted and to measure 18.5–25.7 μ broad and 22.8–37.2 μ long. Winter (76) in 1884 published the description of this *Aecidium* word for word with the description signed by Kühn. Kühn's collections were distributed in Rabenhorst-Winter, *Fungi Europaei* under the name of *Aecidium pseudocolumnare* J. Kühn, nov. sp. number 3027. It is taken for granted then that this material represents the type for *A. pseudocolumnare*. This name, however, came into general use in Europe as a designation of white-spored peridermia on *Abies alba*. That this has been done uncritically is illustrated by the results of comparative examinations made by the writer of spermogonia from several collections found in the herbaria of the Royal Botanic Gardens, Kew, and the British Museum of Natural History — all regarded as *A. pseudocolumnare*. Aeciospores and peridial cells did not prove sufficiently characteristic to be of diagnostic value. Descriptions of the spermogonia of the various collections follow:

(1) Rabenhorst-Winter, *Fungi Europaei* no. 3027, *Aecidium pseudocolumnare* J. Kühn, nov. sp. (bearing Kühn's original description). The spermogonia from this collection are subepidermal and measure 160–200 μ broad and 152–180 μ deep. They closely resemble those of *Milesia vogesiaca*.

(2) Krieger, *Schädliche Pilze unserer Kulturgewächse* no. 74, *Aecidium pseudocolumnare* J. Kühn. The spermogonia are subcuticular and measure 92–140 μ broad and 112–160 μ deep. They most closely resemble those of *Milesia Kriegeriana*.

(3) Krieger, *Fungi Saxonici* no. 1419, *Aecidium pseudocolumnare* Kühn nov. sp. Very little of this material was available but enough was obtained to show a few subcuticular spermogonia measuring 130–132 μ broad and 92–120 μ deep. They also resemble those of *Milesia Kriegeriana*.

(4) C. E. Broome, *Peridermium columnare* on *Picea Nordmanniana* (*Abies Nordmanniana*), Torquay, ex Herb. M. J. B. Aug. 1867. According to J. Ramsbottom, Keeper of Botany, British Museum of Natural History, this material is originally from the herbarium of Miles Joseph Berkeley. Ten spermogonia from a fragment of the specimen were examined. Nine of these are definitely subcuticular while one is subcuticular only in the center with remains of epidermal cells at the sides overlying the spermogonium. They measure 152–208 μ broad and 140–200 μ deep. The evidence is that the subcuticular spermogonia may belong to either or both *Milesia Polypodii* and *M. Scolopendrii*.

(5) M. C. Cooke, Fungi Britannici exsiccati no. 314, *Peridermium columnare* A. & S., near Torquay, Sept. 1869. E. Parfitt. The spermogonia are deep-seated, subcuticular, measuring 128–180 μ broad and 132–180 μ deep. They also may be referable to either or both *Milesia Polypodii* and *M. Scolopendrii*.

(6) *Aecidium pseudocolumnare* Kühn on *Abies alba*. Kelso, Aug. 1925, Malcolm Wilson. Only a small fragment of an infected needle was examined. The sections were not sufficiently satisfactory to warrant a definite conclusion, since the spermogonia seemed to be distorted. They are deep-seated, large, hemispherical, subcuticular and probably belong to the genus *Milesia*.

(7) *Aecidium pseudocolumnare* Kühn. Powerscourt, Co. Wicklow, P. O'Connor. One collection is dated 11.11.31 and 6.2.31, while a second collection is dated 11.11.31. Although this material was collected late in the year, it is in excellent condition. The peridermia even in the dried state are long and unbroken, and almost every leaf on a branch of considerable size is rusted. For convenience the two collections are referred to respectively as (a) and (b). Two spermogonia examined from (a) are deep-seated, hemispherical and measure 101 μ broad and 168 μ deep. These most closely resemble the spermogonia of *Milesia Kriegeriana*. Four spermogonia from (b) were examined. They are deep-seated, subepidermal, elongate and measure 174–181 μ broad and 181–188 μ deep. They closely resemble spermogonia of the type material of *Aecidium pseudocolumnare*.

A study of the spermogonia in these collections, therefore, clearly indicates that the latter are referable to several distinct species. Hence, just as in North America, until recently, several white-spored rusts on *Abies* have been passing under the name *Peridermium balsameum* Peck, so it would seem that the same is true in Europe for *Aecidium pseudocolumnare*.

III. Subfamily CRONARTIEAE

36. *Cronartium ribicola* Fischer

The spermogonia of *Cronartium ribicola* occur on *Pinus Strobus* L. and other five-needle pines. They are caulicolous, subcortical, forming small blisters. They are located between the outermost layer of cortical cells and the periderm, effuse or indefinite in type. Six spermogonia measured 1.0–3.5 mm. broad and 34–67 μ high. Figure 38 represents a mature spermogonium. Sydow (70) states that the spermogonia are about 2.5 mm. long. Colley's (22) observation that "occasionally long filaments grow some distance out beyond the tips of the spermatophores" is of especial interest when viewed in the light of recent discoveries in connection with the fusion of spermatia and haploid hyphae. The spermatia according to Colley are pyriform and measure approximately $2.5 \times 3.5 \mu$.

IV. Subfamily CHRYSOMYXAE

37. *Chrysomyxa Ledi* (A. & S.) DeBary

The spermogonia of *Chrysomyxa Ledi* occur on first year needles of *Picea mariana* (Mill.) B. S. P. and *P. glauca* (Moench) Voss. They are amphigenous, subepidermal and flask-shaped in section (Fig. 37). If the spermogonium happens to form below a stoma the guard cells are carried above the spermogonium. Frequently the epidermal layer, though raised slightly, is left intact; but sometimes the lower walls are attacked and the cells killed. The hypodermal cells within the area of the spermogonium are disrupted, and disappear. The mesophyll cells below the spermogonium are depressed. Twenty-nine spermogonia measured 60–128 μ broad and 45–125 μ high, averaging $105 \times 82 \mu$. The spermatophores arise from a basal stroma and are directed to a slit-like pore in the epidermis. They are usually one-septate near their bases. The spermatia measure $1.5\text{--}2.0 \times 3.0\text{--}3.5 \mu$. They are slightly elongate and form catenulately. The pore through which they are emitted measured 4–35 μ broad and 20–80 μ long.

V. Subfamily COLEOSPORIEAE

38. *Coleosporium Helianthi* (Schw.) Arth.

The spermogonia of *Coleosporium Helianthi* are borne on leaves of *Pinus virginiana* Mill. and *P. echinata* Mill. They are numerous, amphigenous and of the applanate, lenticular type; they resemble those of *Hyalopsora Aspidiotus* in shape except that they are elevated more above the surrounding epidermis and do not depress as much the mesophyll cells of the leaf at maturity. The spermogonia form between the mesophyll and the overlying tissues. The latter consist of an

epidermis, a hypodermis and from one to two layers of thick-walled cells irregularly placed under the hypodermis. The spermogonia are most frequently discrete; but they are sometimes confluent. Twelve spermogonia measured 323–458 μ broad and 92–116 μ high, averaging $361 \times 103 \mu$. The spermatophores are usually single-celled. The spermatia are discharged through a slit 34–92 μ wide. A mature spermogonium showing its relation to the leaf is represented in Fig. 39. In addition to other features, attention should be drawn to long, centrally located hyphae that extend beyond the spermatophores and the level of the epidermis. These are "flexuous hyphae." Such hyphae may extend as much as 15 μ beyond the epidermal level. When the spermogonia have passed full maturity and the spermatia have been discharged there is no trace left of these hyphae. (cf. Arthur 12, 14, Hedgcock 42, Hedgcock and Hunt 43.)

The materials for the study of this and the other species of *Coleosporium* described below were kindly supplied by Dr. G. G. Hedgcock.

39. *Coleosporium inconspicuum* (Long) Hedgc. & Long

The spermogonia of *Coleosporium inconspicuum* are borne on leaves of *Pinus virginiana* etc. The same general description of form and location applies as for the spermogonia of *C. Helianthi*, except that the spermatophores are of slightly smaller diameter. Eleven of them measured 226–317 μ broad and 73–85 μ high, averaging $284 \times 81 \mu$.

The immature spermogonium of *C. inconspicuum* depresses the mesophyll cells lying immediately under it; whereas in the mature spermogonium the latter have regained their normal position with the exception that they may be separated by the strands of mycelium. The cells above the young spermogonium (Fig. 40) are raised and flattened; but on either side of the spermogonium they have retained their normal size and position. Differential staining shows that two layers of mesophyll cells immediately under the spermogonium, in contrast with those more distantly located, have in some way been affected by the parasite. (cf. Arthur 14, Hedgcock 42, Hedgcock and Hunt 43.)

40. *Coleosporium Ipomoeae* (Schw.) Burr.

The spermogonia of *Coleosporium Ipomoeae* occur on needles of *Pinus rigida* Mill. etc. They are subepidermal and of the applanate type. They measure 335–490 μ broad and 104–159 μ high. According to Hedgcock (42) they are olivaceous-black to brownish-black, on slightly chlorotic areas. They are amphigenous in *P. rigida* and hypophyllous in *P. echinata*.

41. *Coleosporium delicatulum* (A. & K.) Hedgc. & Long

The spermogonia of *Coleosporium delicatulum* occur on needles of *Pinus rigida* etc. They are amphigenous, subepidermal, applanate, and measure $354\ \mu$ broad and $110\text{--}122\ \mu$ high. According to Hedgcock (42) they are orange chrome to English red on reddened chlorotic areas.

42. *Coleosporium Laciniariae* Arth.

The spermogonia of *Coleosporium Laciniariae* occur on needles of *Pinus rigida* etc. They are discrete, epiphyllous, subepidermal, applanate and measure $323\text{--}397\ \mu$ broad and $110\text{--}122\ \mu$ high. According to Hedgcock (42) they are olive to olivaceous-black on yellow chlorotic areas. The spermatophores usually are one-septate towards their bases.

43. *Coleosporium Solidaginis* (Schw.) Thüm.

The spermogonia of *Coleosporium Solidaginis* are borne on needles of *Pinus rigida* etc. They are usually discrete. They measure $244\text{--}366\ \mu$ broad and $98\text{--}104\ \mu$ high. In *P. rigida* they are hypophyllous. According to Hedgcock (42) they are grenadine red on slightly reddened chlorotic areas.

44. *Coleosporium Terebinthinaceae* (Schw.) Arth.

The spermogonia of *Coleosporium Terebinthinaceae* occur on needles of *Pinus virginiana* etc. They are epiphyllous and measure $335\text{--}427\ \mu$ broad and $80\text{--}101\ \mu$ high. According to Hedgcock (42) they are "orange rufous to mummy brown, on yellowed chlorotic areas."

45. *Gallowaya pinicola* Arth.

The spermogonia of *Gallowaya pinicola* occur on the leaves of *Pinus virginiana*. They are of the applanate type, lenticular in vertical section, subepidermal and amphigenous. Seven spermogonia measured $244\text{--}427\ \mu$ broad and $48\text{--}92\ \mu$ high. Figure 41 represents a mature spermogonium. The spermogonia are nearly always centrally located beneath the guard cells in stomatal cavities and develop between the mesophyll and the epidermis. The underlying mesophyll cells are not usually depressed and the overlying epidermis is very slightly elevated. The contiguous epidermal cells are never flattened as they may be in *Coleosporium* species; but differential staining shows that their lower walls have been affected by the fungus. The stroma is made up of interwoven hyphae overlying the mesophyll cells; from it spermatophores branch and are arranged periclinally, curving slightly towards a central point under the epidermis. The spermatophores are attenuate, frequently curved at their tips and usually one-septate, about one-third up from the base. Spermatia do not form.

Arthur (16) places *Gallowaya pinicola* in the genus *Coleosporium*. He states that the spermogonia are rudimentary and not externally visible; Dodge (32) previously described them as vestigial or abortive. Dodge further stated that host tissues above the spermogonia are not fully ruptured and that spermatia are seldom formed. Here we have a parallel case to that of *Calyptospora Goeppertiana*. In *G. pinicola* then, as in *C. Goeppertiana*, the spermogonia cannot function in the way described for *Puccinia* species by Craigie (27).

CONCLUSIONS AND SUMMARY

1. The morphology of the spermogonia of representatives of all the genera, except *Chnoospora*, of the Melampsoraceae (Dietel, 1928) has been studied in the course of the investigations recorded in this paper.

2. From these studies it is amply demonstrated that spermogonia are of more or less diagnostic value (just as are other organs) in defining or determining species and genera. The features of chief importance in that connection are the form-type, size and position in the host tissues. It should, of course, be recognized that these features can be employed in diagnosis with greater assurance where the complete life history is known and where the spermogonia have been studied and defined from authentic culture material. This may be illustrated by reference to those species of Melampsoraceae whose haploid stages occur on the Pinaceae. In eastern North America the life histories of many of them have been worked out and the spermogonia have been studied from authentic culture material. It so happens that the *aecial* characters of many of these species are not sufficiently distinctive to enable one to recognize the species or in some cases even the genus from haploid material. The *spermogonial* characters, on the other hand, in many such instances have proved to be of diagnostic value and their characters have been incorporated in definitions of the species. It is now possible, therefore, to recognize many of the Melampsoraceae in eastern North America from haploid material alone and without having recourse to cultures. As for western North America, by contrast, little work has been done on life histories of coniferous rusts. An examination of the spermogonia in western collections of coniferous rusts shows that the spermogonia of some of these rusts are surely of diagnostic value; but the delimitation of species is bound to be tentative until life histories are worked out and the exact morphological characters of their spermogonia are incorporated in descriptions of the species. Much the same condition prevails with respect to the European Melampsoraceae.

3. The spermogonia of the Melampsoraceae may be classified according to their form and position in the host tissues, as follows:

A. *Subcuticular* — (a) pustulate — (1) hemispherical to conoidal
(b) immersed — (1) hemispherical; (2) sub-spherical to spherical

B. *Subepidermal* — (a) applanate
(b) immersed — (1) elliptical; (2) spherical to flask-shaped

C. *Subcortical*

4. Spermogonia have been found for the main part to be characteristic in type for each genus. The one outstanding exception is that of *Melampsora*. In *Melampsora*, as now commonly recognized, two very diverse types of spermogonia are comprised — (1) species in which the spermogonia are robust and deep-seated; (2) species in which the spermogonia are small and pustulate.

Another feature in this connection refers to the importance of giving attention to the spermogonia in surmises as to the genetic position of coniferous rusts where the life histories are unknown. This may be illustrated in such a rust as *Peridermium coloradense*. Certain uredinologists have suggested that it is the haploid stage of a *Melampsorella*; indeed, some have gone so far as to refer it to *Melampsorella Cerastii* (75, 16). An examination of the spermogonia of this rust shows that it cannot possibly be a *Melampsorella*. Its type is that of a *Chrysomyxa*.

5. The spermogonia are of value in establishing or confirming views as to the phylogenetic relationship of genera. An excellent example of this is afforded by the genera *Milesia* and *Uredinopsis*. The similar characters of their spermogonia lend support to the view that these genera are closely related. Another example is afforded by *Pucciniastrum*, *Thecopsora*, *Calyptospora* and *Melampsoridium*, in all of which the spermogonia are morphologically similar.

6. Spermogonia have, as indicated above, been found to be of value in the determination of species from haploid material; in some such instances no help is afforded by aecial characters. For example — *Melampsora americana* and *Caeoma Faulliana*; *Milesia intermedia*, *M. marginalis* and certain other species of *Milesia* as distinct from one another and from species of *Uredinopsis*; and *Calyptospora Goeppertiana* as distinct from various species of *Pucciniastrum*.

7. Attention is called to the non-spermatia-forming rusts, *Calyptospora Goeppertiana* and *Gallowaya pinicola*, as examples of rusts in which spermatia cannot take part in initiating the diploid phase such as is presumed to be the case for *Puccinia graminis*, *P. Helianthi* etc.

8. The ontogeny of the spermogonia has been studied more or less completely for the following species — *Melampsora Abieti-Capraearum*, *M. Larici-Capraearum*, *Melampsorella Cerastii*, *Calyptospora Goeppertiana*, *Hyalopsora Aspidiotus*, *Milesia intermedia*, *M. marginalis*, *M. Kriegeriana*, *M. Polypodii*, *Uredinopsis mirabilis*, *U. Atkinsonii*, *U. Osmundae* and *Coleosporium inconspicuum*.

The value of the ontogenetical studies of some species lies in the circumstance that it is only in this way that the exact type can be determined. Thus a mature spermogonium may appear to be subcuticular when it is really subepidermal or subepidermal when it is really subcuticular.

9. The spermogonia of the Melampsoraceae lack paraphyses. But "flexuous hyphae," possibly receptive organs, extending beyond the aperture of the spermogonium have been found in numerous species of the Melampsoraceae, namely, *Milesia marginalis*, *M. polypodophila*, *M. Kriegeriana*, *M. Polypodii*, *M. Scolopendrii*, *M. vogesiaca*, *Melampsora Abieti-Capraearum* and *Colcosporium Helianthi*. In *Milesia Scolopendrii* spermatia were occasionally attached to "flexuous hyphae" but the nature of the connection was not determined. "Flexuous hyphae" are greater in diameter for most of their length than spermatiphores and are not so much attenuated.

10. Branching of spermatiphores from the stroma has been demonstrated for *Uredinopsis Atkinsonii* and *Pucciniastrum arcticum*. During the development of the spermogonium the distal ends of the spermatiphores remain free from the overlying epidermis or cuticle. At their maturity the spermatiphores are only about one-half the length of the "flexuous hyphae." The spermatiphores decrease in length as they age. Their cells are always uninucleate. Spermatia are borne catenulately. The "slit" through which spermatia are discharged is, in general, parallel to the long axis of the leaf on which the spermogonium is borne.

11. One new species, *Cacoma Faulliana*, is described in this paper.

12. Morphological data on the spermogonia of the species herein studied are summarized below in tabular form (Table II).

TABLE II
SPERMOGONIA OF MELAMPSORACEAE*

Species	Shape (vertical section)	No. meas- ured	Size (breadth \times height in microns) Limits	Average	Remarks
I. SUBFAMILY MELAMPSOREAE					
<i>Melampsora</i> <i>Abieti-</i> <i>Capraearum</i> (<i>M. americana</i>)	Elliptical	67	79-154 \times 42-71	99 \times 48	Subepidermal, depressed
<i>Melampsora</i> <i>Abieti-</i> <i>Capraearum</i>	Elliptical	54	83-138 \times 45-67	110 \times 54	Subepidermal, subdepressed
<i>Caeoma</i> <i>Faulliana</i>	Hemispherical to conoidal	45	42-145 \times 27-49	80 \times 37	Subcuticular, pustulate
<i>Melampsora</i> <i>Abietis-</i> <i>canadensis</i>	Hemispherical flattened to conoidal	34	35-98 \times 15-38 (on needles)	66 \times 25	Subcuticular, pustular
		77	53-128 \times 13-30 (on cones)	78 \times 23	
<i>Melampsora</i> <i>Bigelowii</i>	Hemispherical to conoidal	42	50-102 \times 15-38	69 \times 27	Subcuticular, pustulate
<i>Melampsora</i> <i>Medusae</i>	Hemispherical to conoidal	17	51-105 \times 15-30	75 \times 23	Subcuticular, pustulate
<i>Melampsora</i> <i>Larici-</i> <i>Capraearum</i>	Hemispherical to conoidal	31	30-101 \times 18-38	65 \times 38	Subcuticular, pustulate
II. SUBFAMILY PUCCINIASTREAE					
<i>Melampsoridium</i> <i>betulinum</i>	Hemispherical flattened to conoidal	—	45-53 \times 12-15	—	Subcuticular, pustulate
<i>Melampsorella</i> <i>Cerastii</i>	Hemispherical flattened	72	99-317 \times 27-59	184 \times 38	Subcuticular, pustulate
<i>Pucciniastrum</i> <i>Epilobii</i>	Hemispherical flattened	81	45-212 \times 16-34	95 \times 21	Subcuticular, pustulate
<i>Pucciniastrum</i> <i>Abieti-</i> <i>Chamaenerii</i>	Hemispherical flattened	35	67-196 \times 16-31	102 \times 23	Subcuticular, pustulate

*Notes: 1. Spermogonia on leaves of current season except as indicated under "Remarks".

2. Spermogonia "amphigenous" except as indicated under "Remarks". The term "amphigenous" is used here if spermogonia have been found on both upper and lower leaf surfaces regardless of whether or not they may usually be restricted to one surface or the other.

TABLE II. (Continued)

Species	Shape (vertical section)	No. meas- ured	Size (breadth \times height in microns)		Remarks
			Limits	Average	
II. SUBFAMILY PUCCINIASTREAE. (Continued)					
<i>Pucciniastrum americanum</i>	Hemispherical flattened	29	71-185 \times 18-62	124 \times 35	Subcuticular, pustulate
<i>Pucciniastrum arcticum</i>	Hemispherical flattened	29	100-167 \times 22-51	142 \times 32	Subcuticular, pustulate
<i>Thecopsora minima</i>	Hemispherical flattened to conoidal	34	38-120 \times 15-25	79 \times 20	Subcuticular, pustulate
<i>Thecopsora Myrtilli</i>	Hemispherical to conoidal	15	41-105 \times 15-23	72 \times 20	Subcuticular, pustulate, hypophyllous
<i>Thecopsora Hydrangeae</i>	Hemispherical flattened to conoidal	35	75-126 \times 15-26	99 \times 24	Subcuticular, pustulate
<i>Calyptospora Goeppertiana</i>	Hemispherical to conoidal	105	42-137 \times 13-30	73 \times 21	Subcuticular, pustulate, hypophyllous
<i>Hyalopsora Aspidiotus</i>	Lens-shaped, much flattened	25	311-496 \times 86-117	432 \times 102	Subepidermal, applanate, hypophyllous On second year needles
<i>Milesia intermedia</i>	Hemispherical to subspherical	53	84-137 \times 59-84	110 \times 71	Subcuticular, immersed, hypophyllous
<i>Milesia fructuosa</i>	Hemispherical to subspherical	393	72-180 \times 40-100	123 \times 71	Subcuticular, immersed
<i>Milesia marginalis</i>	Subspherical to almost spherical	50	129-168 \times 92-134	147 \times 106	Subepidermal, immersed
<i>Milesia polypodophila</i>	Spherical	17	175-234 \times 175-243	199 \times 212	Subepidermal, immersed, hypophyllous On leaves 3-8 years old
<i>Milesia Blechni</i>	Somewhat flask-shaped	9	110-175 \times 105-150	—	Subcuticular, immersed
<i>Milesia Kriegeriana</i>	Hemispherical	16	98-168 \times 94-168	129 \times 126	Subcuticular, immersed

TABLE II, (Continued)

Species	Shape (vertical section)	No. meas- ured	(breadth \times height Limits	Size in microns) Average	Remarks
II. SUBFAMILY PUCCINIASTREAE. (Continued)					
<i>Milesia Polypodii</i>	Hemispherical to slightly flask-shaped	34	120-228 \times 105-194	177 \times 162	Subcuticular, immersed
<i>Milesia Scolopendrii</i>	Hemispherical to slightly flask-shaped	28	120-228 \times 100-188	156 \times 140	Subcuticular, immersed
<i>Milesia vogesiaca</i>	Hemispherical to slightly flask-shaped	34	154-241 \times 168-214	201 \times 195	Subcuticular, immersed
<i>Peridermium rugosum</i>	Spherical	11	144-223 \times 144-200	170 \times 169	Subepidermal, immersed, hypophyllous On second- year leaves
<i>Uredinopsis mirabilis</i>	Hemispherical	49	58-123 \times 35-54	89 \times 44	Subcuticular, immersed, hypophyllous
<i>Uredinopsis Atkinsonii</i>	Hemispherical, shallow	65	67-123 \times 36-51	96 \times 48	Subcuticular, immersed, hypophyllous
<i>Uredinopsis Osmundae</i>	Hemispherical, shallow	72	71-134 \times 40-57	104 \times 51	Subcuticular, immersed, hypophyllous
<i>Uredinopsis Phegopteridis</i>	Hemispherical, shallow	68	56-125 \times 34-58	93 \times 48	Subcuticular, immersed, hypophyllous
<i>Uredinopsis Struthiopteridis</i>	Hemispherical, shallow	46	71-129 \times 45-58	94 \times 50	Subcuticular, immersed, hypophyllous
<i>Uredinopsis Pteridis</i>	Hemispherical, vertically elongated	—	100-159 \times 85-110	—	Subcuticular, immersed, hypophyllous On leaves of 1st or 2nd season (?)
<i>Aecidium pseudo- columnare</i>	Subspherical	—	160-200 \times 152-180	—	Subepidermal, immersed

TABLE II. (Continued)

Species	Shape (vertical section)	No. meas- ured	Size (breadth \times height in microns) Limits	Average	Remarks
III. SUBFAMILY CRONARTIEAE					
<i>Cronartium ribicola</i>	Flattened hemispherical	6	1000-3500 \times 34-67	—	Caulicolous, subcortical
IV. SUBFAMILY CHRYSOMYXAE					
<i>Chrysomyxa Ledi</i>	Flask-shaped	29	60-128 \times 45-125	105 \times 82	Subepidermal, immersed
V. SUBFAMILY COLEOSPORIEAE					
<i>Coleosporium Helianthi</i>	Lens-shaped, elevated	12	323-458 \times 92-116	361 \times 103	Subepidermal, applanate
<i>Coleosporium inconspicuum</i>	Lens-shaped, elevated	11	226-317 \times 73-85	284 \times 81	Subepidermal, applanate, hypophyllous
<i>Coleosporium Ipomoeae</i>	Lens-shaped, elevated	—	335-490 \times 104-159	—	Subepidermal, applanate
<i>Coleosporium delicatulum</i>	Lens-shaped, elevated	—	354- \times 110-122	—	Subepidermal, applanate
<i>Coleosporium Laciniariae</i>	Lens-shaped, elevated	—	323-397 \times 110-122	—	Subepidermal, applanate, epiphyllous
<i>Coleosporium Solidaginis</i>	Lens-shaped, elevated	—	244-366 \times 98-104	—	Subepidermal, applanate hypophyllous
<i>Coleosporium Terebinthinaceae</i>	Lens-shaped, elevated	—	335-427 \times 80-101	—	Subepidermal, applanate, epiphyllous
<i>Gallowaya pinicola</i>	Lens-shaped, elevated	7	244-427 \times 48-92	—	Subepidermal, applanate

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EXPLANATION OF PLATES

PLATE 182

- Fig. 1. Lateral vertical section of mature spermatogonium of *Melampsora Abieti-Capraearum* from longitudinal section of leaf of *Abies balsamea*. $\times 700$.
- Fig. 2. Median vertical section of an immature spermatogonium of *Melampsora Abieti-Capraearum* located under guard cell in longitudinal section of leaf of *A. balsamea*. $\times 480$. Note the branched spermatophores.
- Fig. 3. Median vertical section of an immature spermatogonium of *Melampsora Abieti-Capraearum*, approximately $2/3$ mature size, from transverse section of leaf of *A. balsamea*. $\times 212$. Dark areas within spermatogonium are remains of mesophyll cells.
- Fig. 4. Median vertical section of the mature spermatogonium of *Caeoma Fauliana* from a transverse section of leaf of *Abies lasiocarpa*. $\times 135$.
- Fig. 5. Median vertical section of mature spermatogonium of *Melampsorium betulinum* from transverse section of leaf of *Larix decidua*. $\times 280$.
- Fig. 6. Median vertical section of mature spermatogonium of *Melampsora Abietis-canadensis* from cone scale of *Tsuga canadensis*. $\times 325$.
- Fig. 7. Median vertical section of mature spermatogonium of *Melampsora Bigelowii* from longitudinal section of leaf of *Larix laricina*. $\times 280$. Note mass of spermatia above spermatogonium.
- Fig. 8. Median vertical section of immature spermatogonium of *Melampsora Larici-Capraearum* from transverse section of leaf of *Larix laricina*. $\times 330$. Note unbroken elevated cuticle.
- Fig. 9. Median vertical section of mature spermatogonia of *Melampsora Larici-Capraearum* from transverse section of leaf of *Larix decidua*. $\times 280$.

PLATE 183

- Fig. 10. Median vertical section of a mature spermatogonium of *Melampsorella Cerastii* from longitudinal section of leaf of *A. balsamea*. $\times 560$. Note cuticle ruptured at right overlying spermatogonium.
- Fig. 11. Median vertical section of immature spermatogonium of *Calyptospora Goeppertiana* from transverse section of leaf of *A. balsamea*. $\times 413$.
- Fig. 12. Median vertical section of mature spermatogonium of *Puccinias-trum arcticum* from transverse section of leaf of *Picea glauca*. $\times 280$.
- Fig. 13. Median vertical section of mature spermatogonium of *Puccinias-trum arcticum* from transverse section of leaf of *Picea glauca*. $\times 625$. Note cells in stroma from which spermatophores branch.
- Fig. 14. Median vertical section of spermatogonium of *Thecopsora Myrtilli* from transverse section of leaf of *Tsuga canadensis*. $\times 280$.
- Fig. 15. Transverse section of leaf of *A. balsamea* infected with *Hyalospora Aspidiotus*. Note abundance of mycelium in intercellular spaces, spermatogonia and spermatia strewn over leaf surface. $\times 90$.

PLATE 184

- Fig. 16. Median vertical section of spermogonium of *Hyalopsora Aspidiotus* at very early stage in development, from longitudinal section of leaf of *A. balsamea*. $\times 290$.
- Fig. 17. Median vertical section of immature spermogonium of *Milesia intermedia* from transverse section of leaf of *A. balsamea*. $\times 288$. Note depressed epidermal cells, spermatophores and spermatia and overlying unruptured cuticle, with intermediate layer, darkly stained, beneath.
- Fig. 18. Median vertical section of immature spermogonium of *Milesia intermedia* from transverse section of leaf of *A. balsamea*. $\times 888$. Note depressed epidermal cells, separated spermatophores, spermatia and cuticle minus intermediate layer in centre above spermogonium.
- Fig. 19. Median vertical section of very early stage in the development of the spermogonium of *Milesia marginalis* from transverse section of leaf of *A. balsamea*. $\times 550$. Note central cell in epidermis has been invaded.
- Fig. 20. Median vertical section of early stage in the development of the spermogonium of *Milesia marginalis* from longitudinal section of *A. balsamea*. $\times 666$. Note depressed mesophyll cells, spermatophores and central epidermal cell invaded by enlarged hyphae.

PLATE 185

- Fig. 21. Median vertical section of young spermogonium — a later stage than that shown in Fig. 23 — of *Milesia marginalis* from transverse section of leaf of *A. balsamea*. $\times 374$. Note epidermal cells have disappeared.
- Fig. 22. Median vertical section of spermogonium of *Milesia marginalis*, epidermal cells over left, from transverse section of leaf of *A. balsamea*. $\times 280$.
- Fig. 23. Median vertical section of mature spermogonium of *Milesia marginalis* from transverse section of leaf of *A. balsamea*. $\times 280$. Note teeth from outer epidermal wall projecting into spermogonium.
- Fig. 24. Median vertical section of mature spermogonium of *Milesia polypodophila* from transverse section of leaf of *A. balsamea*. $\times 280$. Note two "flexuous hyphae."
- Fig. 25. Median vertical section of an immature spermogonium of *Milesia Polypodii*, showing an early stage of development, from transverse section of leaf of *Abies concolor*. $\times 280$. Note epidermal cells below.
- Fig. 26. Median vertical section of mature spermogonium of *Milesia polypodophila* from transverse section of leaf of *A. balsamea*. $\times 280$. Note shortened spermatophores and chains of spermatia.
- Fig. 27. *Milesia Scolopendrii*, "flexuous hypha" with spermatia attached. $\times 1000$. This is a higher magnification of Fig. 28.

PLATE 186

- Figs. 28 and 29. Photographs of median vertical section of mature spermogonium of *Milesia Scolopendrii* from transverse section of mature leaf of *A. concolor* from hand section, each taken at a different focus. Note flexuous hyphae with spermatia attached.

- Fig. 30. Median vertical section of mature spermatogonium of *Milesia Blechni* from transverse section of leaf of *Abies alba*. $\times 300$.
- Fig. 31. Median vertical section of mature spermatogonium of *Milesia Kriegeriana* from transverse section of leaf of *A. alba*. $\times 300$.
- Fig. 32. Median vertical section of immature spermatogonium of *Milesia Polypodii*, 2/3 mature size, from transverse section of leaf of *A. concolor*. $\times 372$. Note short spermatophores and central core of long hyphae.
- Fig. 33. Mature spermatogonium of *Milesia Polypodii* from transverse section of leaf of *A. alba*. $\times 280$. Note "flexuous hyphae" in central cavity.

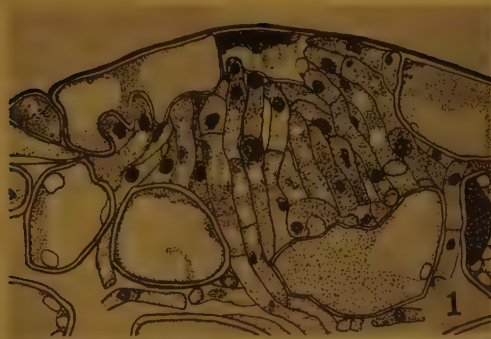
PLATE 187

- Fig. 34. Median vertical section of mature spermatogonium of *Milesia vogesiaca*, from transverse section of leaf of *A. alba*. $\times 300$.
- Fig. 35. Median vertical section of immature spermatogonium of *Uredinopsis mirabilis*, from transverse section of leaf of *A. balsamea*. $\times 446$.
- Fig. 36. Median vertical section of mature spermatogonium of *Uredinopsis Atkinsonii*, from transverse section of leaf of *A. balsamea* to show branching of spermatophores from stroma. $\times 420$.
- Fig. 37. Median vertical section of mature spermatogonium of *Chrysomyxa Ledi*, from transverse section of leaf of *Picea mariana*. $\times 350$.

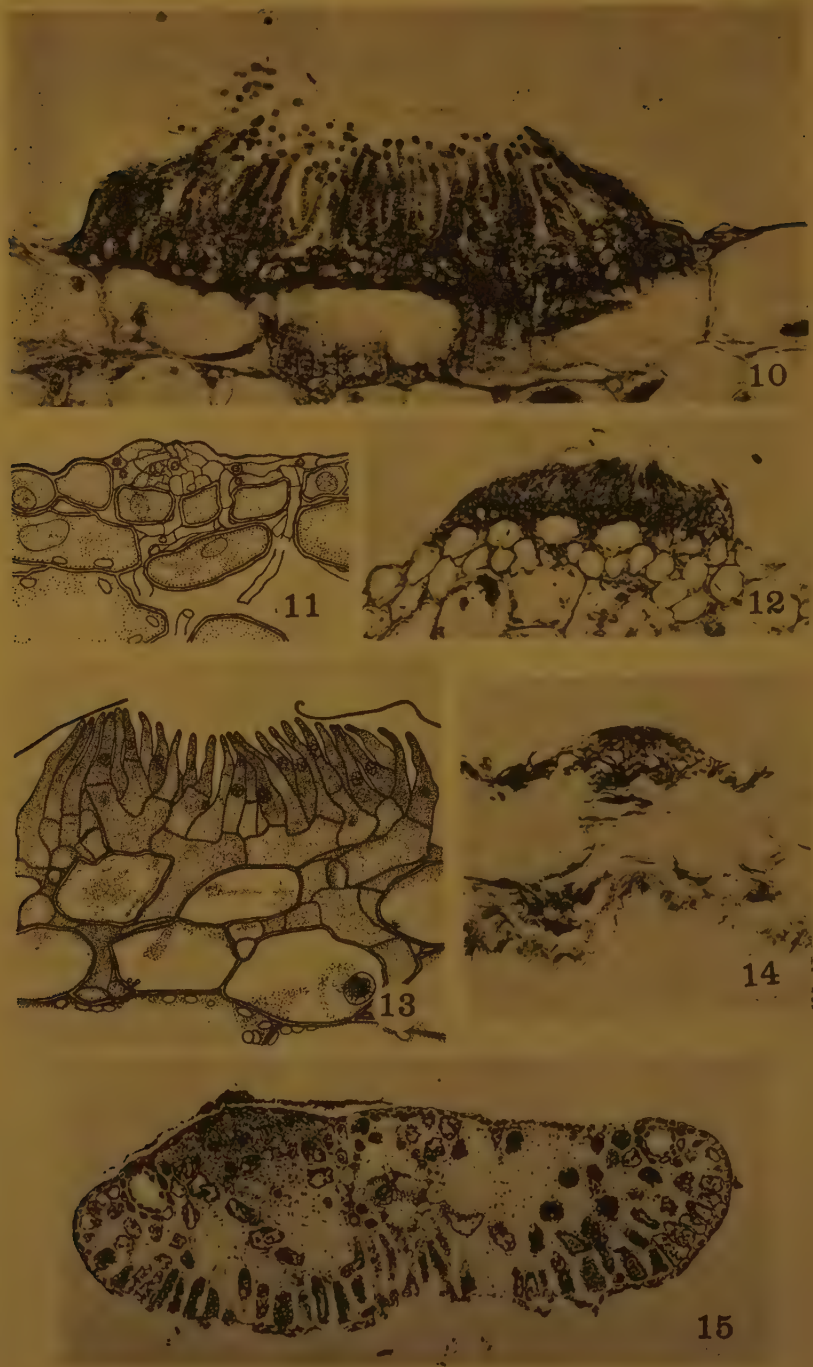
PLATE 188

- Fig. 38. Median vertical section of mature spermatogonium of *Cronartium ribicola* from stem of *Pinus Strobus*. $\times 170$.
- Fig. 39. Median vertical section of mature spermatogonium of *Coleosporium Helianthi*, from transverse section of leaf of *Pinus virginiana*. $\times 170$.
- Fig. 40. Median vertical section of immature spermatogonium of *Coleosporium inconspicuum*, from longitudinal section of leaf of *P. virginiana*. $\times 170$.
- Fig. 41. Median vertical section of spermatogonium of *Gallowaya pinicola* from transverse section of leaf of *P. virginiana*. $\times 142$.

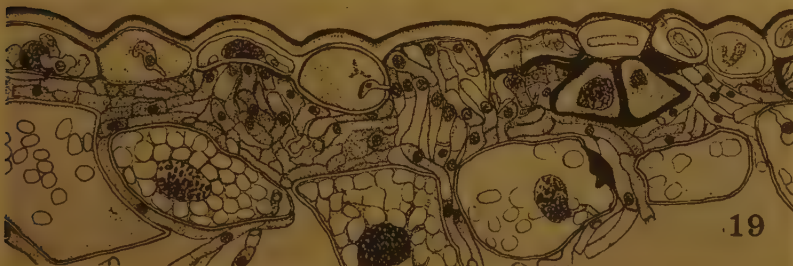
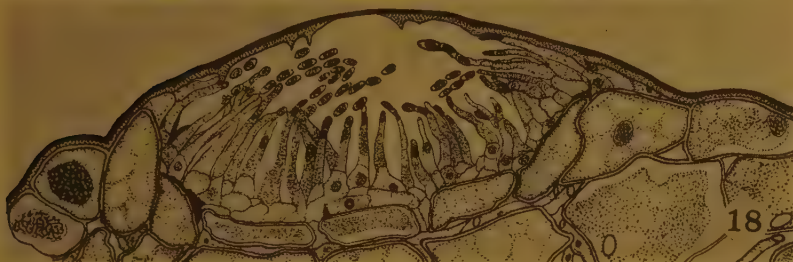
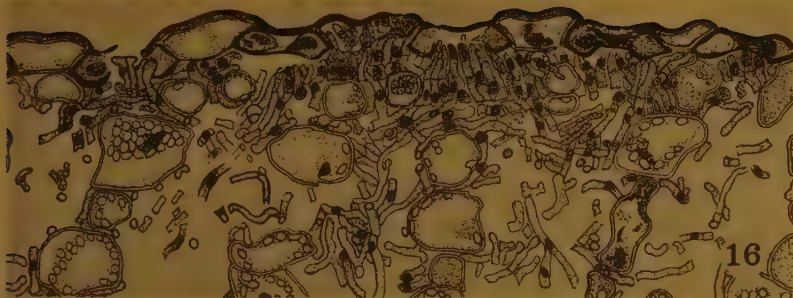
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ARNOLD ARBORETUM, HARVARD UNIVERSITY.



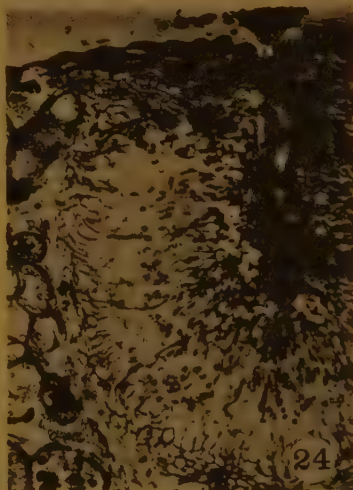
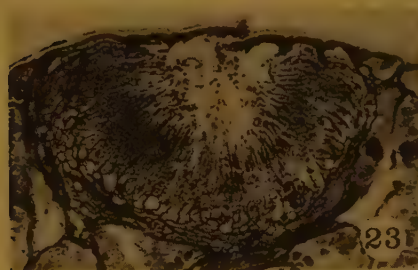
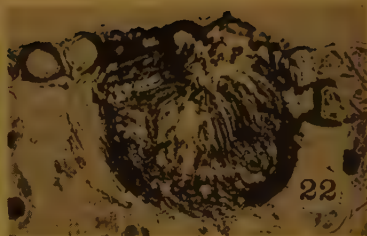
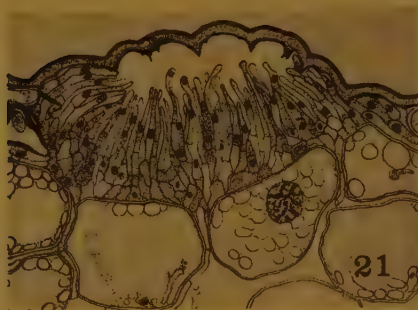
SPERMOGONIA OF THE MELAMPSORACEAE



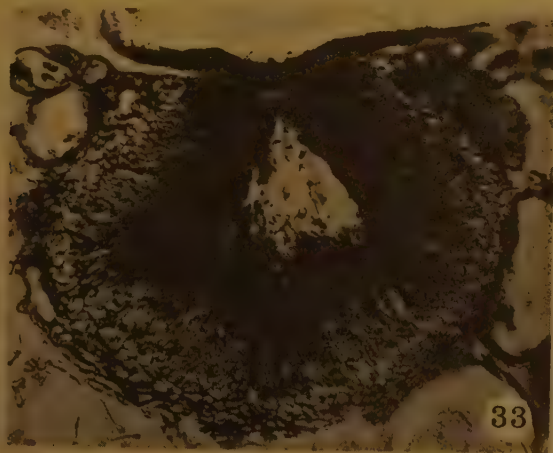
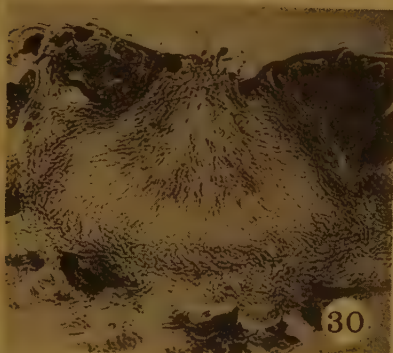
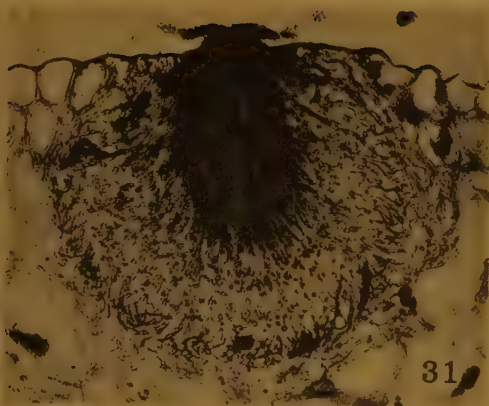
SPERMATOGONIA OF THE MELAMPSORACEAE



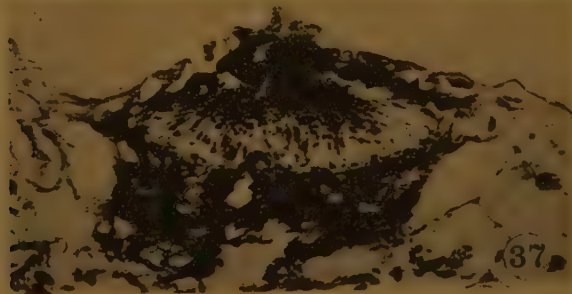
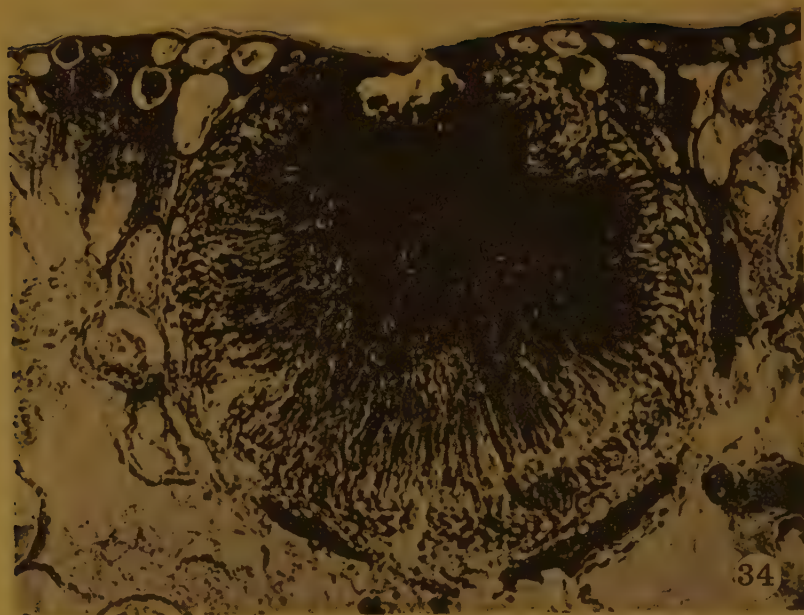
SPERMOGONIA OF THE MELAMPSORACEAE



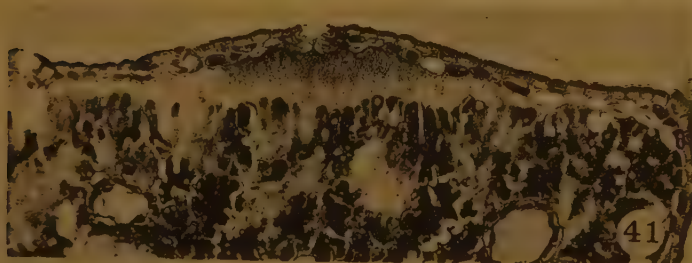
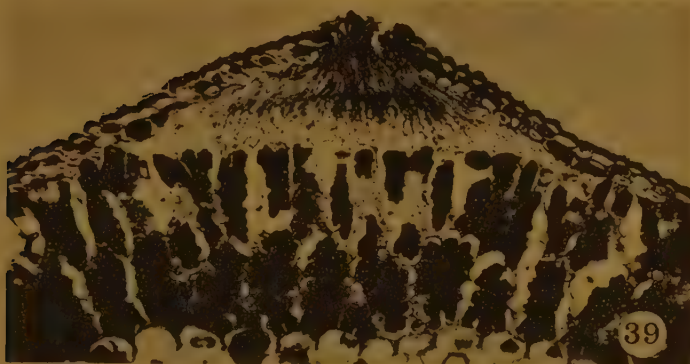
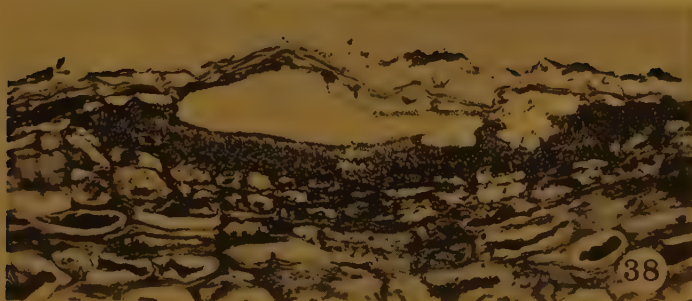
SPERMOGONIA OF THE MELAMPSORACEAE



SPERMATOGONIA OF THE MELAMPSORACEAE



SPERMOGONIA OF THE MELAMPSORACEAE



SPERMOGONIA OF THE MELAMPSORACEAE

THE EXPERIMENTAL PRODUCTION OF POLYPLOIDY

KARL SAX

With plate 189

POLYPLOIDY has played an important rôle in the evolution of the angiosperms, and it is estimated that about half of the angiosperm species are polyploids. Two types of polyploids are known: autopolyploids, involving the reduplication of the same genom; and allopolyploids, involving the duplication of different genoms. The first type of polyploidy is not directly effective in speciation, although the polyploid differs from the diploid in certain morphological and physiological characters. Autopolyploidy does, however, serve to isolate the new form, since it is sterile with, and has a greater range than the diploid ancestor. In a recent survey of autopolyploidy Müntzing (1936) shows that such polyploids are generally more vigorous and hardier than the diploid forms and that the chromosome races are ecologically different. There is also a strong tendency for the polyploids to be perennials. Allopolyploidy is directly effective in producing new species, since such polyploids result from species hybridization, followed by chromosome doubling. The duplication of each of the parental genoms restores fertility, and the hybrid breeds true. Thus the allopolyploid is a constant species hybrid which has the characteristics of a true species, and in the case of generic crosses the allopolyploid may merit generic rank. Allopolyploids are known to occur in nature and in cultivation, and have been produced experimentally in several different families. The various types of allopolyploids have been described by Winge in 1932; and since that time a number of new cases have been discovered, so that we now have records of about fifty allopolyploids, of which eight are known to have originated in nature. It is significant that many of our most important crop plants are of known or supposed allopolyploid origin.

The general occurrence of polyploidy in the angiosperms has led to a detailed study of the causes of chromosome doubling in gametes and egg cells. In 1923 De Mol found that diploid pollen grains could be induced in *Hyacinthus* by subjecting the bulbs to abnormal environmental conditions. Belling (1925) found that low temperatures caused the production of diploid pollen grains in *Stizolobium*, *Uvularia*, and

Datura; and similar results were found in *Epilobium* and *Oenothera* by Michaelis (1928). The experimental work of Sakamura and Stow (1926) showed that high temperatures are also effective in producing diploid pollen grains. Shimotomai (1927) was able to produce giant pollen grains in *Liriope* and in *Scilla* by cold treatment. The effect of temperature treatment is produced by inhibiting the normal meiotic division so that no reduction of chromosomes occurs; but the factors involved are not well known.

The production of diploid gametes is undoubtedly an important factor in the formation of polyploid races or species in nature, even though sterile triploids would be formed more frequently than the relatively fertile tetraploids, especially in cross-pollinated species. The origin of polyploidy by the union of diploid gametes is dependent upon the frequent occurrence of chromosome doubling; but chromosome doubling in the fertilized egg, or at a later stage in somatic development, is directly effective in producing fertile polyploids. This mechanism is known to occur naturally, and has been used under experimental control. Randolph (1932) has been able to double the chromosome number in the fertilized egg cell of *Zea* by subjecting the plant to a temperature of 43°C. for about half an hour at the time the fertilized egg cell was presumably in the resting or early prophase stage. This technique has also been successful with wheat and rye (Dorsey 1936).

EXPERIMENTAL PRODUCTION OF POLYPLOID POLLEN GRAINS

During the past few years we have found occasional diploid pollen grains in plants of *Rhoeo discolor* grown in the greenhouse, where they were subject to moderate variations in temperature. Plants kept in the cold pit, at a temperature of about 5°C. for several days and then returned to the greenhouse, produced many diploid pollen grains. Last year we installed constant temperature chambers where the plants could be kept under control and studied more carefully.

We found that plants of *Rhoeo discolor* would produce some diploid pollen grains when subjected to either high or low temperatures for several days; but more consistent results were obtained when the plants were kept at a temperature of about 10°C. for two or three days and then kept at a temperature of 36°C. for one day. After treatment the plants were returned to the greenhouse and examined every few days.

Under normal conditions the chromosome pair at meiosis to form a ring or chain of 12 chromosomes. Adjacent chromosomes often pass to opposite poles so that each daughter cell receives six chromosomes.

These divide equationally to produce microspores with six chromosomes (Fig. 2). There is usually some irregularity in the chromosome distribution at meiosis, so that about 80 per cent of the pollen grains are sterile and undeveloped. The viable pollen grains contain an elongated dark-staining generative nucleus and a degenerate tube nucleus (Fig. 2A).

The first effect of the temperature treatment is the production of asynapsis. At metaphase the chromosomes are unpaired, and the twelve univalents lie on an equatorial plate (Fig. 1). The equational division of the univalent chromosomes produces a dyad with twelve chromosomes in each cell. In most cases these dyads develop independently to produce diploid microspores (Fig. 3) which develop into diploid pollen grains (3A). Since each microspore contains all twelve chromosomes, there is no deficiency of chromosomes or chromosome segments, and the microspores produce normal pollen grains. There is very little sterility of diploid pollen grains, and certain anthers show almost perfect pollen development as contrasted with about 80 per cent sterility in the normal diploid.

The temperature variation also produces tetraploid microspores. Meiosis is suppressed, and the twelve univalents divide, but there is no nuclear division. The chromosomes pass into the resting stage, and the entire microsporocyte develops as the microspore. There are twenty-four chromosomes in the microspore which divide to form the two nuclei of the pollen grain (Fig. 4). The differentiation of the generative and tube nucleus is seldom complete, although a few giant pollen grains are produced which appear to be normal (Fig. 4A). These tetraploid pollen grains are not produced regularly, and a single anther never contains only this class of pollen grains. They are found in small numbers associated with haploid pollen grains.

In rare cases the univalent chromosomes divide, and the daughter nuclei are formed, but no cell wall is formed to produce a dyad. The microsporocyte functions as a microspore with two nuclei, each with twelve chromosomes. In microspore development each nucleus divides (Fig. 5), and a pollen grain is produced which has two generative and two tube nuclei (Fig. 5A).

Diploid pollen grains have also been produced in species of *Tradescantia*, but only when the plants have been subjected to low and high temperatures. Cold or heat treatment alone is rarely effective in producing polyploid gametes in this genus. The first indication of reaction to temperature treatment is partial asynapsis; further reaction causes complete asynapsis with irregular division of chromosomes; and with

extreme treatment, the univalents divide equationally to form diploid pollen grains.

The effect of temperature treatment appears to be caused by disturbing the synchronization of nuclear and cytoplasmic activities. This effect is especially clear in the development and differentiation of the generative and tube nucleus in microspore development in *Tradescantia* (Sax 1935). In the microsporocyte the temperature change prevents chromosome pairing. The development of the chromosomes is accelerated in relation to other nuclear and cytoplasmic activities so that the univalents are ready to divide at the first instead of the second meiotic division. They may divide before nuclear division is possible so that the chromosome number is doubled. This is the mechanism involved in the production of tetraploid pollen grains of *Rhoeo* and the tetraploid egg cells of *Zea* and *Triticum*.

THE ORIGIN OF POLYPLOIDY IN NATURE

The occurrence of polyploidy in nature has been attributed to extreme temperatures. The tetraploids may have a more northern range than the diploids (Tischler 1935, Anderson and Sax 1936), or a more alpine distribution (Manton 1934), or may show a greater distribution along the seacoast (Tischler 1935). In such habitats a species would be subjected to greater temperature variations. The extreme temperature changes may cause polyploidy as the diploid races extend into unfavorable territory, but it is also possible that the polyploids have originated before the extension of the range, and because they are hardier, they extend their range into more extreme environments.

There are a number of cases where the forms in the northern areas or in extreme environments are more frequently diploid than the related varieties or species in more favorable environments (Böcher, 1936; Rohweder, 1936). One might expect that any extreme change in habitat might induce polyploidy, and that polyploidy would be expected at the periphery of the range, either northern or southern, or at low or high elevations. There is some evidence that different genera vary greatly in response to temperature changes. In many cases there is a definite cycle in gamete development which may serve as an adaptation to extreme diurnal temperatures. In the cereals, for example, the meiotic divisions tend to occur between 6 A. M. and 8 A. M., and it is possible that the more critical prophase stages are synchronized so that they are not often subjected to great variations in temperature.

The experimental evidence obtained with *Rhoeo* and *Tradescantia* indicates that polyploidy may be induced by rather moderate tempera-

ture changes in certain genera, but that rather extreme and sudden changes are more effective. Neither constant heat nor constant cold seems to be effective. Since extreme variations in temperature are most likely to cause polyploidy, one might expect polyploidy in nature to occur in regions of high altitude, in semi-arid regions, or along the sea-coast, where the changes in temperature are often rapid and extreme. The polyploid economic plants appear to have originated in such regions. Of the seven centers of distribution described by Vavilov (1932), five are regions of high elevation. Most of the economic plants of polyploid origin—including apples, pears, wheat, oats, potatoes, tobacco, and upland cotton—have originated in the mountains or foothills in the subtropics or tropics.

The increased vigor and hardiness of the polyploids are known to be associated with an increase in range of distribution in certain genera. We should expect that polyploids might be more frequent than diploids at the periphery of the range. Many species of plants in North America originated in Asia. A comparison of Asiatic and American species grown in the Arnold Arboretum shows that polyploidy is more frequent in the American species of *Malus*, *Rosa*, *Acer*, *Staphylea*, and *Ulmus*, while the reverse is true for *Lonicera* and *Fraxinus*. Many genera, such as *Rhododendron*, are represented entirely, or almost completely, by diploid species in both the old and new world. The data are hardly adequate for a critical survey, but the significance of polyploidy undoubtedly varies in different genera.

EXPERIMENTAL POLYPLOIDY

Work on experimental polyploidy is being conducted at a number of research laboratories. Belling (1925) has called attention to the value of triploids in ornamental plants where seed production is not desired. The use of diploid gametes, formed without a reduction division, should be of value in breeding heterozygous horticultural varieties. In the apple, for example, the varieties are so heterozygous that breeding new varieties is largely a matter of chance; but the union of diploid gametes should combine all the characters of the parental trees.

In the production of auto- and allopolyploids Randolph's method of doubling the chromosome number in the fertilized egg seems to be the most practicable. Our experimental work indicates, however, that it is advisable to precondition the plant in a cold chamber before subjecting the fertilized egg to high temperatures. I have been told that the heat treatment alone is not effective in doubling the chromosomes in *Zea* in the southern states. The failure of chromosome doubling in southern

regions presumably is caused by the relatively high temperatures of the normal environment, so that there is insufficient range of temperature to cause chromosome doubling. Under such conditions the cold treatment is necessary, and probably most plants would show a better response when subjected to an extreme temperature range.

Either the transition from cold to heat or from heat to cold seems to be effective in causing polyploidy. In experimental work the cell activities can be timed somewhat better if the plant is first subjected to cold treatment.

SUMMARY

Plants of *Rhoeo discolor* subjected to sudden temperature changes produced many diploid pollen grains, and a few tetraploid pollen grains. Chromosome doubling is caused by the suppression of meiosis and an equational division of the chromosomes to produce dyads which develop into diploid pollen grains. Occasionally the chromosomes divide without nuclear division to produce a monad which develops into a tetraploid pollen grain. Double diploid pollen grains may be produced which have two generative and two tube nuclei. Chromosome doubling appears to be caused by disturbing the synchronization of nuclear and cytoplasmic activities.

The effect of temperature variations in causing polyploidy in nature is discussed in relation to plant distribution and the centers of origin of cultivated plants. In the experimental production of polyploidy extreme temperature changes are more likely to be successful.

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DESCRIPTION OF PLATE 189

Photographs of microspores and pollen grains of *Rhoeo discolor*. Acetocarmine preparations. $\times 900$.

- Fig. 1. Pollen mother cell with induced asynapsis. The twelve univalents divide equationally.
- Figs. 2 and 2A. A normal haploid microspore with 6 chromosomes, and the normal haploid pollen grain.
- Figs. 3 and 3A. A diploid microspore produced by temperature treatment, and a typical diploid pollen grain.
- Figs. 4 and 4A. A tetraploid microspore induced by temperature treatment, and a well-differentiated tetraploid pollen grain.
- Figs. 5 and 5A. A double diploid microspore produced by equational division of the 12 univalents and nuclear division without cell wall formation. The resulting pollen grain has two generative and two tube nuclei.

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STUDIES IN THE OAKS OF THE MOUNTAINS OF NORTHEASTERN MEXICO

CORNELIUS H. MUELLER

IN two collections of plants made for the Arnold Arboretum in the mountains of Nuevo Leon, Mexico, by the author and Mary Taylor Mueller in 1934 and by the author in 1935 there are 250 numbers of oaks. A field study of considerable intensity from about May 6 to August 15, 1934 and from June 22 to August 15, 1935 has been supplemented by an herbarium study of the specimens collected.

The collecting and field study were carried on in the Sierra Madre Oriental south of Monterrey, Nuevo Leon. The localities cited in the treatment of the species are based upon names appearing on the topographic maps of the republic published by the *Secretaria de Agricultura y Fomento, Departamento de Geografía, Meteorología e Hidrología, Tacubaya, D. F., Mexico*. The maps are known as "*Carta de la República Mexicana en hojas a lã 100,000^a*." Many of the names of ranches and cañons are local names not appearing on any maps. The term *municipio* (Mun.) refers to a political unit comparable to a county. A *municipio* takes its name from the town in which the seat of government is located.

In many of the species there was noted a high degree of variability which undoubtedly has in part led to the description of numerous poorly distinguished species. It will be noted that there are proposed many new names for forms not identical with, but surely conspecific with, previously known entities. These are given the rank of *forma* merely to call attention simultaneously to their differences from, and their conspecificity with, the typical forms with which they are allied, in the hope of avoiding their being regarded as distinct species, as they might readily be if one had not the intergrading forms to study and could not see the trees in the field.

The types of the new species and forms are deposited in the herbarium of the Arnold Arboretum (cited A. A.), Harvard University. The author wishes to acknowledge the excellent coöperation and financial aid of the Arboretum which made possible the collection of these plants.

Subgenus *LEUCOBALANUS* Engelm.Series *POLYMORPHAE* Trelease

Quercus polymorpha Chamisso & Schlechtendal in *Linnaea*, 5: 78 (1830).

NUEVO LEON: Mun. de Monterrey, Cañon Diente, alt. 700 to 1000 m., common on the wooded cañon floor and adjacent slopes, *No.* 252, May 6, 1934; Mun. de Galeana, cañon below Alamar on Hacienda Pablillo, common on the densely wooded cañon floor, alt. 1900 m., *Nos.* 608 & 609, May 29, 1934, *No.* 632, May 30, 1934, *No.* 1143, July 21, 1934.

Quercus polymorpha* f. *angustifolia, f. nov.

A typo recedit foliis anguste lanceolatis (3-4 × 10-14 cm.) integris vel versus apicem angustatum leviter dentatis, acumine plerumque obtuso.

NUEVO LEON: Mun. de Galeana, cañons about Alamar on Hacienda Pablillo, alt. 2000 m., *No.* 610, May 29, 1934, *No.* 1144 (type in A. A.), July 21, 1934; Mun. de Villa Santiago, arroyo bottom between Las Adjuntas and Potrero Redondo, alt. 1300 m., *No.* 2076, July 3, 1935.

Series *GLAUCOIDEAE* Trelease

Quercus clivicola Trelease & Mueller in *Bull. Torr. Bot. Club*, 63: 149 (1936).

NUEVO LEON: Mun. de Galeana, Cañon San Francisco on Hacienda Pablillo, abundant in the pine and oak wood of the cañon floor and slopes, alt. 2000 to 2200 m., *No.* 286, May 10, 1934, *Nos.* 305, 306, & 309, May 11, 1934, *No.* 452, May 18, 1934, *Nos.* 1280, 1285, 1285A, 1286, & 1292, July 31, 1934; common in the oak wood about Taray on Hacienda Pablillo, alt. 2200 m., *No.* 423, May 17, 1934, *No.* 947, July 2, 1934; in Cañon Santa Barbara on Hacienda Pablillo, alt. 2000 m., *No.* 584, May 25, 1934, *Nos.* 1097 & 1098, July 19, 1934; common about Alamar on Hacienda Pablillo, alt. 2000 m., *No.* 974, July 3, 1934, *Nos.* 1103 & 1105, July 20, 1934; Puerto de los Pastores near Galeana, alt. 1500 m., common on openly wooded slopes, *No.* 1007A, July 5, 1934, *No.* 1295, August 2, 1934; Mun. de Monterrey, Cañon Diente, alt. 900 m., common on the wooded cañon floor and slopes, *Nos.* 1306 & 1306B, August 8, 1934; Mun. de Villa Santiago, Cañon Guajuco above Villa Santiago, alt. 1300 m., common on openly wooded slopes, *No.* 1331, August 12, 1934, *No.* 1356, August 15, 1934.

Quercus clivicola* f. *consanguinea C. H. Mueller in *Bull. Torr. Bot. Club*, 63: 150 (1936).

NUEVO LEON: Mun. de Galeana, Cañon Santa Barbara on Hacienda

Pablillo, alt. 2000 m., common in the pine and oak wood of the cañon walls, *No. 583*, May 25, 1934, *No. 1096*, July 19, 1934; about Alamar on Hacienda Pablillo, alt. 2000 m., scattered in the oak wood of relatively open slopes, *No. 1104*, July 20, 1934; Cañon San Francisco on Hacienda Pablillo, alt. 2100 m., abundant in the pine and oak wood of gentle slopes, *No. 1285B*, July 31, 1934.

Quercus clivicola* f. *crenifolia Trelease & Mueller in Bull. Torr. Bot. Club, **63**: 150 (1936).

NUEVO LEON: Mun. de Galeana, Cañon San Francisco on Hacienda Pablillo, alt. 2100 m., common in open oak wood, *No. 388*, May 14, 1934; about Taray on Hacienda Pablillo, abundant on openly wooded, gentle slopes, alt. 2200 m., *Nos. 421, 422, & 425*, May 17, 1934; near Alamar on Hacienda Pablillo, abundant in open oak wood on gentle slopes, alt. about 2000 m., *No. 614*, May 29, 1934, *No. 701*, June 2, 1934, *No. 1145*, July 21, 1934, *Nos. 1173 & 1176*, July 22, 1934; Mun. de Villa Santiago, Potrero Redondo, alt. 1300 m., sparse in the luxuriant pine wood, *No. 2128*, July 5, 1935.

Quercus clivicola* f. *dentata Trelease & Mueller in Bull. Torr. Bot. Club, **63**: 150 (1936).

NUEVO LEON: Mun. de Galeana, Cañon San Francisco on Hacienda Pablillo, alt. 2100 m., abundant constituent of the pine-oak forest, *No. 322*, May 12, 1934, *Nos. 1284 & 1284A*, July 31, 1934; Cañon Santa Barbara on Hacienda Pablillo, alt. 2200 m., common in the pine-oak wood, *No. 1093*, July 19, 1934; Puerto de los Pastores near Galeana, alt. 1500 m., scattered on dry, openly wooded slopes, *No. 996*, July 5, 1934; Mun. de Linares, Cañon Santa Rosa near Iturbide, alt. about 1200 m., scattered in wooded arroyos, *No. 1294*, August 2, 1934.

Quercus clivicola* f. *elongata, f. nov.

A formis aliis differt foliis magis elongatis ($2-3 \times 10-12$ cm.) plerisque supra crenatis vel dentatis.

NUEVO LEON: Mun. de Villa Santiago, Cañon Guajuco above Villa Santiago, alt. 1300 m., common in the low oak wood, *No. 1323* (type in A. A.), August 10, 1934; Mun. de Galeana, Taray on Hacienda Pablillo, alt. 2200 m., *No. 582*, May 25, 1934, *No. 1095*, July 19, 1934.

This form is close to both f. *crenifolia* and f. *dentata* in that the leaves are usually crenate or dentate above.

Quercus glaucophylla von Seemen in Bot. Jahrb. **29**: 95 (1900).

NUEVO LEON: Mun. de Galeana, Taray on Hacienda Pablillo, alt. 2200 m., sparse on the openly wooded slopes, *No. 590*, May 29, 1934; near Alamar on Hacienda Pablillo, alt. 2000 m., common on sparsely

wooded, dry slopes, *No. 596*, May 29, 1934, *No. 1121*, July 21, 1934; Puerto de los Pastores near Galeana, alt. 1500 m., scattered on sparsely wooded, dry slopes, *No. 1002*, July 5, 1934.

***Quercus glaucophylla* f. *lobata*, f. nov.**

A formis aliis differt foliis typicis e basi ad apicem profunde lobatis, sinibus plerisque litteram U simulantibus.

NUEVO LEON: Mun. de Galeana, Cañon San Francisco on Hacienda Pablillo, alt. 2100 m., scattered on openly wooded limestone bluffs, *No. 1281* (type in A. A.), July 31, 1934; Puerto de los Pastores near Galeana, small tree sparse on openly wooded, gentle slopes, *No. 1003*, July 5, 1934.

***Quercus glaucophylla* f. *longifolia*, f. nov.**

Ab aliis formis differt foliis elongatis ($1.5-3 \times 5-7.5$ cm.) supra tantum leviter rotundo-lobatis.

NUEVO LEON: Mun. de Galeana, Taray on Hacienda Pablillo, alt. 2200 m., small tree, sparse in open oak wood on slopes, *No. 589* (type in A. A.), May 29, 1934.

***Quercus glaucophylla* f. *macropetiolata* C. H. Mueller in Bull. Torr. Bot. Club, 63: 151 (1936).**

In some cases this form has much longer petioles than those first described for it from Monterrey, some of them being as long as 16 mm.

NUEVO LEON: Mun. de Galeana, Cañon San Francisco on Hacienda Pablillo, alt. 2100 m., common on openly wooded slopes, *No. 307*, May 11, 1934; Alamar on Hacienda Pablillo, alt. 2000 m., common on openly wooded, dry slopes, *No. 1101*, July 20, 1934, *No. 1200*, July 23, 1934; Puerto de los Pastores near Galeana, alt. 1500 m., scattered on dry, openly wooded slopes, *No. 1001*, July 5, 1934; Mun. de Villa Santiago, Potrero Redondo, alt. 1300 m., common on steep, openly wooded slopes, *No. 2087*, July 4, 1935.

***Quercus glaucophylla* var. *subrotundifolia*, f. nov.**

A formis aliis differt foliis majoribus (ad 5×6 cm.) ovalibus integris vel supra inconspicue crenatis.

NUEVO LEON: Mun. de Galeana, Cañon San Francisco on Hacienda Pablillo, alt. 2100 m., sparse on dry cliffs in the oak wood, *No. 1282* (type in A. A.), July 31, 1934.

***Quercus verde*, sp. nov.**

Arbor parva ramis gracilibus (1-2 mm.) sulcatis incano-tomentosis, annotinis pubescentibus, lenticellis sparsis minutis vel majusculis conspicuisque; gemmae primum ovoideae et vix 1 mm. diam., demum acute ovoideae ad 2.5×3.5 mm. magnae, glabrae; stipulae subulatae, 5 mm.

longae, plerumque persistentes. Folia decidua, oblonga vel obovata, obtusa, saepe mucronulata, leviter cordata, integra vel apicem versus dentibus paucis latis brevibusque mucronulatis, margine minute revoluta plano vel crispo, supra lucidula et sparsissime stellata, subtus pallidiora, pilis stellatis canescentia, venis utrinsecus 8 vel 9 ramosis et anastomosantibus supra non sed subtus manifeste elevatis; petioli circiter 0.5–1 × 5–9 mm., dense stellato-pilosi. Amenta mascula 2.5–3.5 cm. longa, laxa, stellato-pilosa, antheris glabris breviter exsertis; amenta feminea 2–4-flora, pedunculo incano 1–2.5 cm. longo. Fructus annuus, non visus.

NUEVO LEON: Mun. de Galeana, Cañon San Francisco on Hacienda Pablillo, alt. 2100 m., scattered in low oak wood on a hilltop, *No.* 373 (type in A. A.), May 14, 1934, *No.* 451, May 18, 1934; Cieneguillas on Hacienda Pablillo, alt. 2500 m., sparse in scrubby oak wood, *No.* 886, June 17, 1934.

A moderately small tree with rather gnarled branches and scaly gray bark. It occurs infrequently in open oak wood. From all other species of the section GLAUCOIDEAE except *Q. sororia* Liebm. (Overs. Dansk. Vidensk. Selsk. Forhandl. 1854, p. 175) this species differs in having twigs stellately incanous the first year and still quite hairy the second. From *Q. sororia* it differs in its very slender twigs and leaves hairy beneath. Its relationship to any one species in the series is problematic.

× *Quercus pastorensis*, hybr. nov. (*Q. glaucophylla* von Seemen × *Q. clivicola* Trel. & C. H. Muell.).

Ramuli, gemmae et fructus ut in *Q. glaucophylla*; ramuli et folia subtus persistenter pubescentes ut in *Q. clivicola*; folia nervatione *Q. glaucophyllam* referentia, sed textura et forma (oblonga margine crenata) *Q. clivicolae* similia.

NUEVO LEON: Mun. de Galeana, Puerto de los Pastores near Galeana, alt. 1500 m., common on openly wooded, dry slopes, *No.* 1296 (type in A. A.) & 1297, August 2, 1934, *Nos.* 1000 & 1005, July 5, 1934. *Nos.* 1000 & 1297 seem to have resulted from a back cross with *Q. glaucophylla*. In them the characters of *Q. clivicola*, especially the hairiness of the leaves, are somewhat less evident.

Although the parents of this hybrid occur mixed over much of the range covered by this report, as well as in the type locality of the proposed hybrid, nowhere else was there noticed any evidence of hybridization. Since the type locality is a rather poor site bearing little woody vegetation, it may be that the hybrid is in this case less vigorous than the parents and therefore confined to an area in which the rigors of drought have much reduced the competition. It is doubtless true that many of the species reported in Mexico are hybrids which cannot be

recognized as such because of the extremely small amount of field study which has been carried on.

Series AURANTIACAE Trelease

Quercus monterreyensis Trelease & Mueller in Bull. Torr. Bot. Club, 63: 151 (1936).

NUEVO LEON: Mun. de Monterrey, Cañon Diente, alt. 600 m., sparse in the dense oak wood, *No. 256*, May 6, 1934; Mun. de Villa Santiago, Cañon Guajuco above Villa Santiago, alt. 1300 m., common in rather dense oak wood along arroyos and on slopes, *No. 1315*, August 10, 1934, *Nos. 1328 & 1329*, August 12, 1934; Potrero Redondo, alt. 1300 m., scattered in open oak wood on gentle slopes, *No. 2080*, July 3, 1935.

Of these specimens *No. 1328* differs considerably from the other specimens in having leaves about half normal size both surfaces of which are sparsely stellate hairy. These differences hardly merit a name even as a form, for they often occur on the same tree as typical leaves and are to be regarded as a part of the normal variation of the species.

Series RETICULATAE Trelease

Quercus reticulata Humboldt & Bonpland, Pl. Aequinoct. 2: 40 (1809).

NUEVO LEON: Mun. de Galeana, Cañon San Francisco on Hacienda Pablillo, alt. 2100 m., abundant along wooded waterways, *Nos. 303 & 304*, May 11, 1934, *No. 1279A*, July 31, 1934; above Alamar on Hacienda Pablillo, alt. 2300 m., sparse in low oak scrub, *No. 747*, June 4, 1934; Cañon de Cieneguillas above Pueblo San Francisco, alt. 2400 m., scattered along wooded waterways, *Nos. 1271 & 1272*, July 27, 1934.

This polymorphic species is quite difficult to delimit, for there appears to be as much variation within the species as there is between it and some others of the series, notably *Q. rhodophlebia* Trelease (in Mem. Nat. Acad. Sci. 20: 74. 1924), *Q. Uhdeana* Trelease (l. c. 75), and *Q. pilicaulis* Trelease (l. c. 67).

Quercus reticulata f. squarrosa Trelease in Mem. Nat. Acad. Sci. 20: 75 (1924).

NUEVO LEON: Mun. de Galeana, Cañon San Francisco on Hacienda Pablillo, alt. 2100 m., sparse with the species along arroyos, *No. 1279*, July 31, 1934.

Quercus reticulata f. longa Trelease in Mem. Nat. Acad. Sci. 20: 75 (1924).

NUEVO LEON: Mun. de Galeana, Cañon San Francisco on Hacienda

Pablillo, alt. 2100 m., sparse with the species along arroyos, *No. 1279B*, July 31, 1934.

This form, like the above, is not distinct from the species but grades into it.

***Quercus reticulata* f. *pungens*, f. nov.**

A typo recedit foliis 1.5×3 cm. vel minoribus profunde mucronatodentatis in dimidio superiore, margine revolutis et manifeste undulatis.

NUEVO LEON: Mun. de Derrumbadero, Cañon de los Capulines above San Enrique on Hacienda San Jose de Raices, alt. 2500 m., shrub, rare on dry, shrub-covered slopes, *No. 2417* (type in A. A.), August 6, 1935.

***Quercus revoluta* Trel.¹ f. *acuta*, f. nov.**

A typo recedit foliis magis elongatis ($1-1.5 \times 2-3.5$ vel 2×5 cm.) apice mucronatis acutissimis, dentatis vel integris, tomento subtus satis sparso.

NUEVO LEON: Mun. de Galeana, Puente de Dios near Galeana, alt. 1200 m., abundant shrub on dry, shrub-covered hills, *No. 2169* (type in A. A.), July 12, 1935.

***Quercus Loeseneri* Trelease in Mem. Nat. Acad. Sci. 20: 79 (1924).**

NUEVO LEON: Mun. de Galeana, slopes about Cieneguillas on Hacienda Pablillo, alt. 2400 m., sparse in the shrubs of the dry hills, *No. 882*, June 17, 1934; Cerro Potosí near Galeana, alt. 2700 to 3300 m., abundant low shrub in the pine forest, *No. 1263*, July 26, 1934, *Nos. 2225 & 2239*, July 20, 1935, *No. 2286*, July 24, 1935.

The distinction of this species from *Q. reticulata* seems very doubtful.

Series MICROPHYLLAE Trelease

***Quercus microphylla* Née in Anal. Cienc. Nat. 3: 264 (1801).**

NUEVO LEON: Mun. de Galeana, Cañon San Francisco on Hacienda Pablillo, alt. 2100 m., sparse shrubs on low-wooded slopes, *Nos. 1291B & 1291X*, July 31, 1934.

The preceding specimens are doubtfully referred to this species.

Probably the most confused group of white oaks and the last which will be satisfactorily understood is comprised of the various scrubby species of the desert mountain areas of northern Mexico and adjacent southwestern United States. One group, which seems to center about *Q. microphylla* and *Q. chihuahuensis* Trel., is represented in these collections by twenty numbers. The specimens show definite affinities to several species, but by reason of their high degree of intergrading can

¹Trelease in Mem. Nat. Acad. Sci. 20: 79 (1924).

only tentatively be referred to any species. It seems apparent that one of two conditions must be recognized. There might be an intricate system of closely related species which would many times multiply the number now known. To follow such an assumption would defeat the purpose of taxonomy. The only alternative which seems at present applicable is that there has been a high incidence of hybridization coupled with the natural variations of a profoundly fluctuating group of organisms. To classify satisfactorily such an entanglement will require field study of literally thousands of specimens and can hardly be undertaken in the study of a limited area such as the one now under consideration.

Series CHIHUAHUENSES Trelease

Quercus chihuahuensis Trelease in Mem. Nat. Acad. Sci. **20**: 85 (1924).

NUEVO LEON: Mun. de Galeana, Cañon San Francisco on Hacienda Pablillo, alt. 2100 m., abundant low shrub on low-wooded slopes, *Nos.* 312 & 320, May 12, 1934, *Nos.* 1036 & 1037, July 15, 1934, *Nos.* 1288, 1288A, 1291, & 1291A, July 31, 1934; about Pablillo on Hacienda Pablillo, alt. 2000 to 2100 m., *Nos.* 535 & 536, May 21, 1934, *No.* 885, June 17, 1934, *No.* 1091, July 18, 1934; above Alamar on Hacienda Pablillo, alt. 2200 m., common low shrub in dry, open wood, *No.* 748, June 4, 1934, *No.* 1158A, July 22, 1934; Cerro Infernillo on Hacienda Pablillo, alt. 3000 m., a common shrub in the pine forest, *No.* 847, June 17, 1934; Cañon de las Placetas above Pueblo San Francisco, alt. 2300 m., abundant as an undergrowth in pine and oak wood, *No.* 1274, July 27, 1934; Cerro Potosí above Derramadero, alt. 2700 m., abundant low or creeping shrub in the pine forest, *No.* 2280, July 22, 1935; Arroyo Hondo near San Enrique on Hacienda San Jose de Raices, abundant on dry, shrub-covered slopes, *No.* 2311, July 31, 1935; Mun. de Villa Santiago, pass above Potrero Redondo, alt. 2100 to 2300 m., abundant in the shrub zones, *No.* 2134, July 7, 1935.

The preceding specimens have been referred only tentatively to this species.

Series OPACAE Trelease

Quercus Pringlei von Seemen in Bot. Jahrb. **29**: 96 (1900).

NUEVO LEON: Mun. de Galeana, about Pablillo on Hacienda Pablillo, alt. 2000 to 2300 m., sparse on dry, shrub-covered hills, a low shrub, *No.* 880, June 17, 1934, *No.* 1090, July 18, 1934; Puerto de los Pastores, alt. 1500 m., rare on dry, openly wooded slopes, *No.* 995A, July 5, 1934; Mun. de Derrumbadero, hills above San Juanito, alt. 2300 m., abundant shrub on dry slopes, *No.* 2420, August 10, 1935.

***Quercus Pringlei* f. *dentata*, f. nov.**

A typo recedit foliis circiter triente inferiore excepto dentatis dentibus incurvis mucronatis, subtus initio flavo-stellato-tomentosis demum glabratiss.

NUEVO LEON: Mun. de Galeana, about Pablillo on Hacienda Pablillo, alt. 2000 m., rare shrub on dry slopes, *No. 881* (type in A. A.), June 17, 1934.

Series UNDULATAE Trelease

***Quercus undulata* Torr. *Vaseyana* Rydberg** in Bull. N. Y. Bot. Gard. **2**: 218 (1901).

NUEVO LEON: Mun. de Rayones, Casillas, alt. 1400 m., scattered on very dry and sparsely shrub-covered slopes, *No. 2167*, July 9, 1935. TAMAULIPAS: Mun. de Villa Mainero, bajada east of the mountains and north of Villa Mainero, alt. 500 m., rare in the dense scrub thorn forest, *No. 2431*, August 14, 1935.

The specimens agree perfectly with *Q. sillae* Trelease (in Mem. Nat. Acad. Sci. **20**: 102. 1924) which is described from the vicinity of Monterrey, Nuevo Leon, a short distance to the north of the localities here cited. There is no apparent morphological distinction and no reason why *Q. undulata* should not range south over similar habitats from western Texas.

Series PRINOIDEAE Trelease

***Quercus Muehlenbergii* Engelm** in Trans. Acad. St. Louis **3**: 391 (1877).

NUEVO LEON: Mun. de Galeana, Alamar on Hacienda Pablillo, alt. about 1900 m., large tree abundant in the densely wooded cañons, *Nos. 623 & 651*, May 30, 1934, *No. 1120*, July 21, 1934.

Series VIRENTES Trelease

***Quercus fusiformis* Small** in Bull. Torr. Bot. Club, **28**: 357 (1901).

NUEVO LEON: Mun. de Villa Santiago, Cañon Denuncio above Rancho La Bola, alt. 750 m., abundant small tree in the more xerophytic oak wood, *No. 2013*, June 23, 1935.

Subgenus ERYTHROBALANUS Oersted

Series VIMINEAE Trelease

***Quercus duraznillo* Trelease** in Mem. Nat. Acad. Sci. **20**: 122 (1924).

NUEVO LEON: Mun. de Galeana, Cañon San Francisco on Hacienda Pablillo, alt. 2100 m., shrub abundant on open slopes, *Nos. 369* (with definite indications of evergreen habit) & *374*, May 14, 1934, *Nos. 1289*,

1289A, & 1290, July 31, 1934; Cerro Infernillo above Cieneguillas on Hacienda Pablillo, alt. 2700 m., common in low oak wood, *No.* 845, June 17, 1934; Mun. de Derrumbadero, hills above San Juanito, alt. 2500 m., common on very dry, open slopes, *No.* 2419, August 10, 1935.

In most of the collections the leaves tend to be toothed, but not so deeply as in *f. pinetorum* Trelease (in *Mem. Nat. Acad. Sci.* 20: 123. 1924). The male catkins are scarlet when they first appear. The fruit is annual, paired on a short stalk, the cup scales shiny, light brown, almost glabrous, rounded or even truncate at the apex.

Series CRASSIFOLIAE Trelease

Quercus errans* Trel.¹ *f. graciliramis*, *f. nov.

A typo differt ramis gracilibus 2 mm. crassis et petiolis brevioribus; praeterea foliis manifeste sempervirentibus saepe ad basin dentatis et apice minus frequenter acutis.

NUEVO LEON: Mun. de Galeana, above Pablillo on Hacienda Pablillo, alt. about 2200 m., low shrub common in the dense, low oak wood of steep slopes, *Nos.* 394 (syntype in A. A.), 395, and 401, May 14, 1934; Cañon de las Placetas above Pueblo San Francisco, alt. 2000 m., common low shrub on densely shrub-covered steep slopes, *No.* 1273 (syntype in A. A.), July 27, 1934; Cerro Potosí above Derrumbadero, alt. 2800 m., abundant shrub 20 to 50 cm. high on pine-covered slopes, 1 to 2 m. high in arroyos, *No.* 2224, July 20, 1935.

The specimens show distinctly the biennial fruiting habit, and in some the catkins are well preserved. The latter have not been described for the species: staminate catkins 4–7.5 cm. long, the peduncle loosely hairy, rather densely flowered above and loosely below, the stamens exserted. Pistillate catkins 10–20 mm. long, 3–5-flowered, usually only the basal one developing into a single subsessile fruit.

Series ARISTATAE Trelease

***Quercus Endlichiana* Trelease in *Mem. Nat. Acad. Sci.* 20: 141 (1924).**

NUEVO LEON: Mun. de Galeana, slopes above Alamar on Hacienda Pablillo, alt. 2200 m., small tree about 7 m. tall, forming a dense wood, *Nos.* 719 & 720, June 4, 1934, *Nos.* 1159, 1161, & 1162, July 22, 1934; Mun. de Villa Santiago, Cañon Guajuco above Villa Santiago, alt. 1400 m., small tree or shrub 3 to 6 m. tall, abundant in pine and oak forest, *No.* 1330, August 12, 1934.

Quercus Endlichiana f. minor*, *f. nov.

A typo differt foliis parvis (2–3.5 × 4–6.5 cm.) leviter dentatis denti-

¹Trelease in *Mem. Nat. Acad. Sci.* 20: 131 (1924).

bus setaceo-aristatis vel supra profunde incisis.

NUEVO LEON: Mun. de Galeana, slopes above Alamar on Hacienda Pablillo, alt. 2200 m., small tree about 4 m. tall, scattered in the pine and oak wood, *Nos.* 718, 728, & 729, June 4, 1934, *Nos.* 1157 (type in A. A.) & 1158, July 22, 1934; Mun. de Villa Santiago, Potrero Redondo, alt. 1400 m., moderate tree some 8 m. tall, growing on a dry, openly wooded slope, *No.* 2112, July 4, 1935, *No.* 2127, July 5, 1935.

***Quercus Endlichiana* f. *serrata*, f. nov.**

A typo differt folius profunde incisis supra acute serratis.

NUEVO LEON: Mun. de Galeana, slopes above Alamar on Hacienda Pablillo, alt. 2200 m., small tree about 4 m. tall, scattered in the pine and oak wood, *No.* 727, June 4, 1934, *No.* 1160, July 22, 1934; near Taray on Hacienda Pablillo, alt. 2200 m., moderate tree about 7 m. tall, sparse in the pine and oak wood, *Nos.* 585 & 587, May 25, 1934; Mun. de Villa Santiago, Cañon Guajuco above Villa Santiago, alt. 1400 m., moderate tree abundant in oak and pine wood, *No.* 1330A (type in A. A.), August 12, 1934; Potrero Redondo, alt. 1400 m., moderate tree about 8 m. tall, abundant in the pine and oak forests, *No.* 2126, July 5, 1935.

These specimens and those of f. *minor* grade into one another almost imperceptibly.

Certain numbers of the series representing this species (notably *Nos.* 1160, 1330 and 1330A) very pointedly indicate a close relationship to *Q. aerea* Trelease (in Mem. Nat. Acad. Sci. 20: 135. 1924.) in general appearance, leaf form, and “. . . resiniferous beneath so as to be of the color of ‘bronzey old gold’ . . .”. The only point upon which certain of these specimens can be excluded from *Q. aerea* is that of the small round-ovoid buds of that species, and even so, certain of the less mature specimens of this series fit that description. Perhaps a comparison of this material with the types of *Q. Endlichiana* and *Q. aerea* would prove them identical. The description of the latter, however, is fragmentary, and it is to be hoped that the more fully described *Q. Endlichiana* be allowed to stand.

Series RYSOPHYLLAE Trelease

Quercus rysophylla Weatherby in Proc. Amer. Acad. 45: 423 (1910).

NUEVO LEON: Mun. de Galeana, Alamar on Hacienda Pablillo, alt. 1900 m., tall tree, 20 to 25 m., common on densely wooded cañon floors, *Nos.* 625 & 633, May 30, 1934, and *No.* 1123, July 21, 1934; Mun. de Villa Santiago, Potrero Redondo, alt. 1400 m., common on densely wooded cañon floors, 15 to 25 m. tall, *No.* 2113, July 4, 1935.

Series EUGENIAEFOLIAE Trelease

***Quercus pinnativenulosa*, sp. nov.**

Arbor parva ramulis glabris gracilibus sulcatis, lenticellis fulvis conspicuis; gemmae subfusiformes, circa 1.5×3 mm. magnae, acutae. Folia ut videtur decidua, subcoriacea, integra, anguste ovata vel pleraque lanceolata, utrinque acuta, raro basi late cuneata, satis parva (2×5 to 3×12 cm.), supra et infra glabra et lucida, venis utrinsecus circa 18 utrinque prominulis, tenuioribus alternantibus, fere horizontaliter divergentibus, juxta marginem minute revolutum manifeste anastomosantibus; petioli supra satis applanati, circa $1 \times 3-5$ mm., apicem versus lamina decurrente alati. Amenta mascula 4-5 cm. longa, laxa; inflorescentiae femineae pleraeque biflorae, circa 5 mm. longae. Fructus biennis; cupula leviter involuta, circa 12 mm. lata et intus 6 mm. alta; glans (immatura) ovoidea, leviter sericea, dimidio immersa, circa 6×12 mm. magna.

NUEVO LEON: Mun. de Villa Santiago, Cañon Guajuco above Villa Santiago, alt. 1400 m., scattered along an arroyo in open pine and oak wood, a moderately small tree with dark gray or black bark roughly furrowed or smooth on young trees, *No. 1342* (type in A. A.), August 13, 1934.

The relationship of this species to the EUGENIAEFOLIAE is quite plain in the short petioles, the entire glabrous leaves, and the number, forking, and horizontal disposition of the veins. It is most closely related to *Q. eugeniaefolia* Liebmann (in Overs. Dansk. Vidensk. Selsk. Forhandl. 1854, p. 145) from which it is distinguished by the revolute leaf margins, less prominently winged and longer petioles, and usually less prominent veins beneath as well as by its being entirely glabrous save the staminate catkins and the cup scales. *Quercus eugeniaefolia* f. *petiolata* Trelease (in Mem. Nat. Acad. Sci. 20: 161. 1924.) is closer to *Q. pinnativenulosa* in appearance according to Trelease's illustration (pl. 316b), but the same illustration shows the former to be annual fruited which the proposed new species is definitely not. The meagerness of published descriptions makes the distinction of this species difficult even though the great discrepancy in range and the quite different appearance would lead one to expect a more ready distinction.

Series LANCEOLATAE Trelease

***Quercus affinis* Scheidweiler in Hort. Belg. 4: 321 (1837).**

NUEVO LEON: Mun. de Galeana, Cañon San Francisco on Hacienda Pablillo, alt. 2100 m., abundant along densely wooded waterways, a slender, moderate tree, *No. 310*, May 11, 1934, *No. 1283*, July 31, 1934; Cañon Santa Barbara on Hacienda Pablillo, alt. 2200 m., abundant in

dense pine and oak wood, *No.* 579, May 25, 1934; Taray on Hacienda Pablillo, alt. 2100 m., abundant in low, dense oak wood, *No.* 1102, July 20, 1934; Cañon de las Placetas above Pueblo San Francisco, alt. 2100 m., common along a densely wooded waterway, *No.* 1232, July 25, 1934; between Puerto de Agua Sarca above Alamar on Hacienda Pablillo and Los Toros, alt. 2000 to 2500 m., *Nos.* 2422 & 2423, August 10, 1935, *No.* 2424, August 11, 1935.

Series TRIDENTES Trelease

Quercus chrysophylla Humboldt & Bonpland in Pl. Aequinoct. 2: 42 (1809).

NUEVO LEON: Mun. de Galeana, Cañon de las Placetas above Pueblo San Francisco, alt. 2200 m., rare along a wooded waterway, *No.* 1231, July 25, 1934.

Series MEXICANAE Trelease

Quercus mexicana Humb. & Bonpl. f. ***Bonplandii*** Trelease in Mem. Nat. Acad. Sci. 20: 174 (1924).

NUEVO LEON: Mun. de Galeana, Cañon San Francisco on Hacienda Pablillo, alt. 2100 m., abundant on openly wooded slopes, *No.* 308, May 11, 1934, *No.* 1100, July 19, 1934.

Series SALTILLENSES Trelease

Quercus flocculenta, sp. nov.

Frutex vel arbor parva ramulis 1–2 mm. crassis sulcatis stellato-incanis vel glabrescentibus; gemmae acute ovoideae, 1.5×2 mm. magnae. Folia decidua, firma et subcoriacea, 1–2 \times 3–7 cm. magnae, anguste lanceolata vel oblonga, pleraque acuta, basi rotundata vel late subcuneata, integra vel apicem versus dentibus pluribus vel uno aristatis, margine plana, supra lucida et sparse stellato-pilosa secus costam et ad basin, subtus tomento stellato-canesciente detergibili, et facie denudata minutissime bullato-granulari, venis utrinsecus 8–10, ramosis et anastomosantibus, subtus prominentibus supra vix visibilibus, reticulo venularum leviter elevato; petioli 0.5×4 –7 mm. tomento canesciente persistente sed detergibili; stipulae cito caducae. Amenta masculo circa 3 cm. longa, laxa, stellato-pilosa; amenta feminea 1–2-flora, pedunculo 1–2 \times 5–10 mm. magno stellato-piloso. Fructus annuus; cupula juvenilis obconica squamis obtusis puberulis vel interdum glabris.

NUEVO LEON: Mun. de Galeana, Cañon de Cieneguillas above Pueblo San Francisco, alt. 2400 m., abundant on openly wooded slopes, shrub or small tree with low, spreading habit, *No.* 1277 (type in A. A.), July 27, 1934; slope of Cerro Potosí above Derramadero, alt. 2800 m., low tree abundant along a cut-over waterway, *No.*

2279, July 22, 1935; Mun. de Derrumbadero, above San Juanito toward Agua Sarca, *No.* 2418, August 10, 1935, *No.* 2427, August 11, 1935.

The slender petioles, raised and looping venation, and the acute, usually entire, crisped leaves of *Q. flocculenta* indicate a relationship to the SALTILLENSIS. But the rather extreme canescence of the leaves and twigs accentuates the differences between this species and those of the series SALTILLENSIS, so that one hesitates to include it therein although it fits more readily there than elsewhere.

***Quercus flocculenta* f. *incisa*, f. nov.**

A typo recedit foliis supra profunde incisib lobis aristatis, margine revoluto crispato.

NUEVO LEON: Mun. de Galeana, Cañon de Cieneguillas above Pueblo San Francisco, alt. 2400 m., common with the species, *No.* 1276 (type in A. A.), July 27, 1934; near Pablillo on Hacienda Pablillo, alt. 2200 m., common on rather dry slopes in piñon and scrub oak wood, *No.* 802, June 15, 1934.

***Quercus flocculenta* f. *oblongifolia*, f. nov.**

Ab aliis formis differt foliis oblongis 2-6 cm. longis subtus minus pubescentibus.

NUEVO LEON: Mun. de Galeana, Cañon de Cieneguillas above Pueblo San Francisco, alt. 2400 m., along arroyos in more mesophytic habitats with the species, *Nos.* 1229 (type in A. A.) & 1230, July 25, 1934, *No.* 1275, July 27, 1934; Mun. de Villa Santiago, puerto above Potrero Redondo, alt. 2300 m., abundant in the scrub oaks of a ridge top, *No.* 2129, July 7, 1935.

***Quercus galeanensis*, sp. nov.**

Frutex ramulis dense breviter stellato-pilosis, demum furfuraceis sulcatis 1-1.5 mm. crassis; gemmae acutae, 1 × 2 mm. magnae. Folia firma et crassa, oblonga vel lanceolata 0.8-1.5 × 2-3.5 cm. magna, integra vel supra profunde et setose dentata, pleraque acuta, basi cuneata vel rotundata vel cordata, margine manifeste revoluta, glabra basi costae supra et ima basi laminae ciliata exceptis, nervis utrinsecus 5-8 cm. cum intermediis, utrinque leviter elevatis, vix anastomosantibus in dentes si adsunt exeuntibus, angulo angusto divergentibus; petioli 1 × 3-5 mm. magni, glabri facie superiore excepta. Fructus annui solitarii vel bini pedunculo 2-8 mm. longo suffulti; cupula juvenilis squamis majusculis arcte appressis obtuse brunneo-acuminulatis glabris.

NUEVO LEON: Mun. de Galeana, hills about Puente de Dios near Galeana, alt. 1200 m., abundant on dry slopes, *No.* 2168 (type in A. A.), July 12, 1935.

This species seems closely related to *Quercus saltillensis* Trelease from which it may be distinguished by the usual toothing, the localization of pubescence, and glossy lower surfaces of the leaves of *Q. galeanensis*. It is a large shrub abundant on dry slopes associated with piñon, sumac, and other low oaks.

Quercus saltillensis Trelease in Mem. Nat. Acad. Sci. 20: 183 (1924).

NUEVO LEON: Mun. de Galeana, slopes of Cerro Infernillo above Cieneguillas on Hacienda Pablillo, alt. 2700 m., common in low oak wood, Nos. 845 & 848, June 17, 1934; below Cieneguillas on Hacienda Pablillo, alt. 2200 m., sparse in shrub zones on dry hillsides, No. 887, June 17, 1934; Cañon San Francisco on Hacienda Pablillo, common on open, shrub-covered hills, No. 1290, July 31, 1934.

Series ACUTIFOLIAE Trelease

***Quercus alamarensis*, sp. nov.**

Arbor parva, glabra ramulis gracilibus 1.5–2 mm. crassis sulcatis conspicue lenticellatis; gemmae ovoideae, obtusae, 1.5×2 mm. magnae, squamis obscure brunneis leviter ciliolatis. Folia decidua, anguste lanceolata, $2-3 \times 8-12$ cm. magna, integra vel raro setis una vel duobus marginalibus instructa, longe acuta, basi rotundata vel late cuneata, supra lucide glauco-viridia, subtus cuprea, nervis utrinsecus circiter 10 ramosissimis et anastomosantibus, ut costa utrinque elevatis; petioli $1 \times 15-20$ mm. Amenta feminea biflora pedunculo 3–6 mm. longo; squamae cupula juvenilis squamis leviter verruculosus. Fructus annuus.

NUEVO LEON: Mun. de Galeana, Alamar on Hacienda Pablillo, alt. 2000 m., rare in open wood along arroyos, No. 613 (type in A. A.), May 29, 1934.

Small tree with roughly furrowed, black bark and a moderately branched habit. It is only by the nature of the veins that this tree can be entirely excluded from the species *Quercus Canbyi* Trel., although its leaf form would make it quite a strange phase of that species.

Quercus Canbyi Trelease in Mem. Nat. Acad. Sci. 20: 188 (1924).

NUEVO LEON: Mun. de Galeana, Alamar on Hacienda Pablillo, alt. 1900 to 2100 m., common in wooded cañons, Nos. 615 & 616, May 29, 1934, No. 1177, July 22, 1934, Nos. 1203 & 1225, July 23, 1934; Puerto de los Pastores, alt. 1500 m., scattered on open slopes, Nos. 1007 & 1008, July 5, 1934; Cañon Santa Barbara on Hacienda Pablillo, alt. 1900 m., abundant in a densely wooded waterway, No. 1094, July 19, 1934; Mun. de Monterrey, Cañon Diente, alt. 800 m., abundant on

openly wooded, dry slopes, *No. 1305*, August 8, 1934; Mun. de Villa Santiago, Cañon Marisio Arriba above Las Adjuntas, alt. 1300 m., abundant on drier slopes, *No. 2051*, June 25, 1935; Potrero Redondo, alt. 1500 m., common on drier slopes, *Nos. 2090 & 2100*, July 4, 1935.

The forms of this species are many of them doubtless only ecological phases. They are significant taxonomically only because of the danger of their being regarded as distinct species.

***Quercus Canbyi* f. *attenuata*, f. nov.**

A typo differt omnibus partibus diminutis; ramulis 1–2 mm. crassis, gemmis 2 mm. longis, foliis 1–1.5 × 5–7 cm. magnis, cupula 9–10 mm. diam.; arbor parva.

NUEVO LEON: Mun. de Villa Santiago, Cañon Guajuco above Villa Santiago, alt. 1300 m., scattered with the species on dry slopes, *No. 1347* (type in A. A.), August 15, 1934; Mun. de Galeana, Puerto de los Pastores near Galeana, alt. 1500 m., sparse on dry slopes, *No. 1010*, July 5, 1934.

***Quercus Canbyi* f. *Karwinskii* (Trel.), comb. nov.**

Quercus Karwinskii Trelease in Mem. Nat. Acad. Sci. 20: 188 (1924).

NUEVO LEON: Mun. de Galeana, Puerto de los Pastores, alt. 1500 m., sparse with the species on dry, open wooded slopes, *No. 1006*, July 5, 1934.

Specimens have been collected which approach variously this proposed species of Trelease, and the one collection which seems undoubtedly to fit here shows by its relation to intergrades that it cannot be held distinct from *Q. Canbyi*. The chief character upon which *Q. Karwinskii* is distinguished in Trelease's key, that of cup scales not canescent, is encountered in various forms as well as typical *Q. Canbyi*. Notable intergrades in these collections are *Q. Canbyi* f. *setacea* and *No. 999* of f. *subovatifolia*.

***Quercus Canbyi* f. *pedunculata*, f. nov.**

Differt a forma *attenuata* pedunculis 5–8 mm. longis.

NUEVO LEON: Mun. de Galeana, Puerto de los Pastores, alt. 1500 m., rare with the species, *No. 1009* (type in A. A.), July 5, 1934.

***Quercus Canbyi* f. *setacea*, f. nov.**

A typo differt foliis lobis multo longioribus ad 15 mm. setaceo-aristatis aristis 5–6 mm. longis, apice longe attenuatis et plerumque integris.

NUEVO LEON: Mun. de Galeana, Puerto de los Pastores, alt. 1500 m., rare with the species, *No. 1011* (type in A. A.), July 5, 1934.

***Quercus Canbyi* f. *subovatifolia*, f. nov.**

Differt foliis tenuioribus, ad 4.5 × 11 cm. magnis, basi saepe obtuse subcuneatis vel rotundatis.

NUEVO LEON: Mun. de Galeana, Puerto de los Pastores, alt. 1500 m., scattered on dry slopes with the species, *No.* 999, July 5, 1934; Alamar on Hacienda Pablillo, alt. 2000 m., common along densely wooded waterways, *No.* 12034, July 23, 1934; Mun. de Villa Santiago, Cañon Guajuco above Villa Santiago, alt. 1200 m., scattered with the species on closely wooded slopes, *No.* 1346, August 15, 1934.

This form cannot be satisfactorily distinguished from the species, but its broad leaves together with minor differences, such as leaf texture very fine, give it such an aberrant appearance that only the many intergrades restrain one from regarding some of the specimens as distinct species. Leaves as large as 4.5×11 cm., the bases often obtusely sub-cuneate to broadly rounded. This form arises most commonly under conditions of shade and abundant moisture. It is an artificial group, and no one of the specimens cited may be designated as a type.

Quercus Sartorii Liebmann in Overs. Dansk. Vidensk. Selsk. Forhandl. 1845, p. 177.

NUEVO LEON: Mun. de Villa Santiago, Potrero Redondo, alt. 1500 m., sparsely scattered in open oak wood on rather dry, gentle slopes, low tree, *No.* 2123, July 5, 1935.

***Quercus cupreata*¹ f. *brachystachys*, f. nov.**

A typo differt lenticellis prominentibus, foliis basi rotundatis vel sub-cuneatis, amentis femineis 5 mm. longis vel brevioribus (in typo 10–20 mm. longis).

NUEVO LEON: Mun. de Villa Santiago, Cañon Guajuco above Villa Santiago, alt. 1400 m., common in dense oak wood, *No.* 1327 (type in A. A.), August 12, 1934; Cañon Denuncio above Rancho La Bola, alt. 900 m., sparse along a wooded waterway, *No.* 2011, June 22, 1935.

The specimens of this form bear mature fruits which are here described because those of the species are yet unknown: cups moderate (12–14 mm.), shallow (5 mm.), moderately inrolled, scales light brown, dark tipped, elongated and narrowly rounded, somewhat scurfy and ciliate; acorns small (10–11 mm. broad, 7–9 mm. long), hemispherical (flat at the base), obtusely conic above, depressed at the apex, silky, minutely striate.

Quercus cupreata* f. *serrata Trelease & Mueller in Bull. Torr. Bot. Club, 63: 153 (1936).

NUEVO LEON: Mun. de Villa Santiago, Potrero Redondo, alt. 1400 m., abundant on densely wooded cañon walls, *Nos.* 2078 & 2079, July 3, 1935, *No.* 2102, July 4, 1935.

¹Trelease & Mueller in Bull. Torr. Bot. Club, 63: 152 (1936).

***Quercus graciliramis*, sp. nov.**

Arbor glabra domatiis inconspicuis interdum in foliis repertis exceptis, ramulis 2–2.5 mm. crassis, manifeste sulcatis lenticellis parvis instructis; gemmae acutae, conicae, 1.5×2.5 mm. magnae. Folia decidua, lanceolata vel anguste ovata, $3.5\text{--}7 \times 8\text{--}13$ cm. magna, basi subcuneata, leviter serrata ad profunde incisa lobis in setas tenues 3–5 mm. excurrentibus, sinubus levibus vel profundis rotundatis, supra opaca, infra lucida et cuprea, margine plana nervis utrinsecus 4 vel 5 ut venulis leviter prominentibus; petioli supra applanati, $1 \times 20\text{--}30$ mm. Amenta feminea 5–10 mm. longa, 2–3-flora, pedunculo $1.5 \times 5\text{--}7$ mm. Fructus biennis; cupula juvenilis turbinata, margine leviter involuta, squamis tenuibus planis anguste rotundatis ciliatis canescentibus detergis pallide brunneis; glans juvenilis leviter stellato-puberula ad apicem applanatam et rotundatam.

NUEVO LEON: Mun. de Galeana, Alamar on Hacienda Pablillo, alt. 1900 to 2100 m., abundant along densely wooded waterways, *No. 1106* (type in A. A.), July 20, 1934, *No. 617*, May 29, 1934, *No. 1124*, July 21, 1934, *No. 1202*, July 23, 1934; Taray on Hacienda Pablillo, alt. 2100 m., common along waterways, *No. 1224*, July 23, 1934.

Moderate tree with long graceful branches and roughly furrowed, dark gray or black bark. The affinities of this species for *Quercus runcinatifolia* Trelease & Mueller (in Bull. Torr. Bot. Club, **63**: 153. 1936) as regards leaf characters and for other species of the section in fruit characters are no more marked than its apparently close relationship to *Q. albocinta* Trelease (in Mem. Nat. Acad. Sci. **20**: 193. 1924) upon which is based the series ALBOCINTAE Trel. Since the fruits of *Q. albocinta* are unknown, any comparison (or distinction) must be based upon leaf characters. In this regard the typical form of *Q. graciliramis* closely approximates *Q. albocinta*, and there comes to mind the suggestion that the series ALBOCINTAE may be more closely related to certain species of the ACUTIFOLIAE than are some of the species of the latter to one another. The only characters upon which there can be based any great distinction between *Q. albocinta* and the species of ACUTIFOLIAE are that in the former the veins invariably pass into the lobes, and that the leaf margins are broadly crisped. These characters may be seen as tendencies in *Q. graciliramis* and *Q. runcinatifolia*, and in the latter the white veins of *Q. albocinta* are quite common. *Quercus graciliramis* is readily distinguished from *Q. runcinatifolia*, to which it is closely related, by the fine texture of its leaves and by its prominent lenticels. When the fruits of *Q. runcinatifolia* become known, there will probably be more readily describable differences.

***Quercus tenuiloba*, sp. nov.**

Arbor alta, glabra domatiis inconspicuis interdum in foliis repertis exceptis, ramulis 3 mm. crassis sulcatis obscure rubro-brunneis lenticellis prominentibus demum canescentibus lenticellis minus conspicuis instructis; gemmae conicae, 2×3 mm. magnae, acutae, apice pubescentes, squamis obscure brunneis ciliatis. Folia decidua, anguste attenuato-lanceolata, raro latiora, $3.5-5.5 \times 12-17$ cm. magna, basi quadrato-rotundata vel leviter cordata, pleraque supra leviter incisa sinubus rotundatis, lobis brevibus in setas 4-8 mm. longas exeuntibus, lobo terminali plerumque elongato-acuta, margine cartilagineo leviter revoluta, supra opaca, subtus lucida, cuprea, nervis utrinsecus 10-12 supra impressis subtus prominentibus, trabeculis satis conspicuis conjunctis, ramosis sed vix anastomosantibus; petioli supra applanati et leviter alati, $1.5 \times 10-22$ mm., plerique 20-22 mm. Amenta feminea biflora, circa 8 mm. longa. Fructus biennis; cupula juvenilis rotundata squamis tenuibus appressis canescentibus tomento deterso pallide brunneis.

NUEVO LEON: Mun. de Galeana, Alamar on Hacienda Pablillo, alt. 1900 m., sparse in densely wooded arroyos, *No. 1125* (type in A. A.), July 21, 1934, *No. 652*, May 30, 1934, *No. 1146*, July 21, 1934; Mun. de Villa Santiago, Cañon Marisio Arriba, above Las Adjuntas, alt. 1400 m., sparse in densely wooded waterways, *No. 2045*, June 25, 1935.

Large, tall tree with roughly furrowed, black bark, growing sparsely on very moist and densely wooded cañon floors. *Quercus tenuiloba* is quite distinct from other species of the series ACUTIFOLIAE, but it is apparently rather closely related to *Q. Grahamei* Benth (Plant. Hartweg. 57. 1840) and *Q. xalapensis* Humboldt & Bonpland (Pl. Aequinoct. 2: 24. 1809) from both of which it may be distinguished by its veins impressed above and its squarely rounded leaf bases.

***Quercus tenuiloba* f. *gracilis*, f. nov.**

A typo differt ramulis gracilibus 1.5-2 mm. crassis, foliis valde angustatis basi truncatis vel obtuse cuneatis; petiolis 3-4 mm. longis.

NUEVO LEON: Mun. de Villa Santiago, Cañon Marisio Arriba, above Las Adjuntas, alt. 1400 m., moderate, slender tree rare along densely wooded waterways, *No. 2048* (type in A. A.), June 25, 1935.

***Quercus tenuiloba* f. *hirsuta*, f. nov.**

A typo differt ramulis hornotinis pilosis, annotinis furfuraceis, foliis subtus ad costam nervosque et supra ad basin costae stellato-pilosis; petiolis 6-10 mm. longis.

NUEVO LEON: Mun. de Villa Santiago, Potrero Redondo, alt. 1500

m., moderate, spreading tree sparse on openly wooded slopes, *No.* 2122 (type in A. A.), July 5, 1935.

Quercus vexans Trelease in Mem. Nat. Acad. Sci. **20**: 190 (1924).

NUEVO LEON: Mun. de Villa Santiago, Cañon Guajuco above Villa Santiago, alt. 1500 m., abundant in dense oak wood on steep slopes, *Nos.* 1326 & 1332, August 12, 1934; Potrero Redondo, alt. 1400 to 1800 m., abundant constituent of dense oak wood on broad slopes, *No.* 2121, July 5, 1935, *No.* 2130, July 7, 1935.

No. 1332 exhibits what is apparently secondary growth giving the appearance of biennial fruit and evergreen foliage. The general fruiting habit, however, does not warrant any such conclusion.

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PHYTOGEOGRAPHIC STUDIES IN THE ATHABASKA — GREAT SLAVE LAKE REGION

I. CATALOGUE OF THE VASCULAR PLANTS

HUGH M. RAUP

With plates 190–194 and map

INTRODUCTION

THE Athabaska–Great Slave Lake region lies in the central latitudes of the Mackenzie drainage basin of northwestern Canada, and occupies the eastern part of this central section. Roughly, it involves an area some 500 miles long by 350 miles wide, lying west of the 105th meridian and north of the 55th parallel. It consists almost entirely of virgin wilderness devoid of roads or other means of transportation except the primitive ones of the natural waterways and the sharply contrasting modern ones of the air. As a result of the difficulties of transport, especially in the country which does not lie immediately along the great rivers or lake shores, any detailed studies in natural history are bound to be greatly limited in geographic scope. In attempting generalizations, therefore, on the ranges of species or vegetations, it must be borne in mind constantly that there are vast “inland” areas which are virtually unknown biologically, and that many of these areas are terra incognita as well to the geologist and topographer. With very few exceptions the data upon which the following studies have been based were gathered from the “marginal” strips. The only hinterlands which have been examined with any degree of care are in the Wood Buffalo Park.

The present paper, containing a catalogue of the known vascular flora of this region, is to be followed by another devoted to a general description of the country and its vegetation, with historical notes on its botanical exploration. Taken together these papers are intended to form the third of a series of similar studies dealing with the central and southern portions of the Mackenzie basin.^{1, 2} It will be noted at once

¹RAUP, HUGH M. *Phytogeographic Studies in the Peace and Upper Liard River Regions, Canada, with a Catalogue of the Vascular Plants*. Contr. Arnold Arb. VI. (1934).

²——— *Botanical Investigations in Wood Buffalo Park*. Nat. Mus. Can. Bull. no. 74 (Biol. Ser. No. 20) (1935).

that the area involved in the paper on the Wood Buffalo Park is included in that of the present one. To avoid duplication in the catalogue, and at the same time to make it usable for the whole region, detailed citations of Wood Buffalo Park specimens will be largely omitted, and notes on the occurrence of species there only summarized. On the other hand, since the vegetational studies to follow this catalogue are concerned mainly with the pre-Cambrian regions to the eastward of the Slave and lower Athabaska Rivers as well as about the eastern arm of Great Slave Lake, it has seemed advisable to permit a certain amount of overlap, and to include citations of specimens collected in the great river lowlands along the western borders of the crystalline rocks. The southern boundary of the area would, by this reasoning, be in the lower Athabaska valley, but here it has been extended southward rather arbitrarily so as to include the small amount of available botanical information about the Clearwater River country and that along the Athabaska up as far as Athabaska Landing. While studying earlier botanical records the writer has made a fairly exhaustive survey of the literature, and has been able to see most of the specimens in American herbaria collected in the entire Mackenzie basin except for the upper Athabaska River region. Consequently it has been possible to summarize for this larger area the known distribution of the species listed. It should be noted that collections made in recent years by A. E. & R. T. Porsild in the Great Bear Lake and lower Mackenzie districts may be expected to add greatly to our knowledge of many of these northern plant ranges.

The first comprehensive account of the flora of the Mackenzie basin was that contained in the classic *Flora Boreali-Americana*, by W. J. Hooker. It was completed in 1840, and so far as our region was concerned, was based almost entirely upon the collections made by John Richardson, that remarkable physician-naturalist who, between 1819 and 1827, accompanied the first and second expeditions of John Franklin through the northern interior of Canada. Very few additions to the known flora were made during the century following these expeditions. Macoun's Catalogue of Canadian Plants, the publication of which was finished in 1890, depended almost entirely, for its records in our region, upon Hooker's *Flora*. The only collection of particular note in this long interval was that of Robert Kennicott, made about 1860, but no account of it was ever published, nor has it been as a whole easily available to students. An excellent description of the ligneous flora was presented by E. A. Preble as a result of his biological reconnaissance work (chiefly zoölogical) in the Mackenzie basin in 1901 and 1903-4.¹

¹PREBLE, E. A. *A Biological Investigation of the Athabaska-Mackenzie Region*. U. S. Dept. Agr. — N. Am. Fauna No. 27 (1908).

The writer's own collecting was begun in the summer of 1926 on the lower Athabaska River and the northwest shore of Lake Athabaska. This has been followed by six other journeys to various parts of the region, netting about 4880 field numbers of vascular plants. This collection, together with its accumulated field notes, forms most of the foundation for the present catalogue. Wherever the earlier records could be authenticated by actual specimens, they have been included, and unauthenticated records have been noted in the text if they form significant or suggestive range extensions. In 1926 the known vascular flora of the entire Mackenzie basin east of the Rocky Mountains included approximately 600 species. In the past ten years this figure has been increased by something over 35%, with each new effort making substantial additions.

A more or less detailed history of the earlier collectors will be placed in another paper, as noted above. There also will be found a description of the writer's own itineraries. For present purposes the accompanying map and the following list of most of the collection localities should be sufficient to make the catalogue geographically intelligible.

Athabaska River and tributaries

Methye Portage: Lat. $56^{\circ}40'$, Long. $109^{\circ}54'$. On the height of land between the Saskatchewan and Mackenzie drainages.

Clearwater River: Collections noted thus came from the valley of this stream somewhere between Methye Portage and the Athabaska. Most of them evidently came from very near the Portage, since they are marked "Sask."

Waterways: A small settlement on the Clearwater River about 4 miles from McMurray by road. It is at the end of the railroad from Edmonton, and the present head of navigation on the Mackenzie waterways system.

McMurray: Lat. $56^{\circ}44'$, Long. $111^{\circ}23'$. At the junction of the Clearwater and Athabaska Rivers.

Athabaska Landing: Lat. $54^{\circ}45'$, Long. $113^{\circ}15'$. A town on the Athabaska River connected with Edmonton by road and train.

Lac la Biche: A lake about halfway between Edmonton and Waterways along the railroad. It drains westward into the Athabaska River. The town, from which a few specimens are cited, is at the eastern end of the lake.

Pelican Rapids: A small rapid in the Athabaska about 120 miles below Athabaska Landing.

Grand Rapids: An unnavigable rapid in the Athabaska about 85 miles above McMurray.

Calumet: Lat. $57^{\circ}25'$, Long. $111^{\circ}38'$. Collections are from the east bank of the Athabaska and neighboring uplands about 7 miles below Calumet Creek, just above Wheeler's Island.

Firebag River: Lat. $58^{\circ}43'$, Long. $111^{\circ}21'$. Collections are from woods and sloughs along this stream 2–3 miles above its entrance to the Athabaska.

Delta of Athabaska River: Collections are mainly from two localities, one near the mouth of the Embarras Channel (Lat. $58^{\circ}36'30''$, Long. $111^{\circ}5'30''$) and the other on Mamawi (Cree) Creek (Lat. $58^{\circ}29'$, Long. $111^{\circ}30'$).

Lake Athabaska

Chipewyan: Lat. $58^{\circ}42'32''$, Long. $111^{\circ}10'$.

Shelter Point: Lat. $58^{\circ}50'$, Long. $110^{\circ}50'$.

Sand Point: Lat. $58^{\circ}56'$, Long. $110^{\circ}42'$.

Charlot Point: Lat. $59^{\circ}36'$, Long. $109^{\circ}13'$. See map for details of collection localities (Ellis Bay, Charlot Isl., Charlot River, Camsell Portage).

Elliot Point: A small point about 8 miles east of Crackingstone Point (see map).

Cornwall Bay: Lat. $59^{\circ}27'30''$, Long. $108^{\circ}27'30''$. See map for detail of collection localities (Wabba Lake, etc.).

Fishhook Bay: Lat. $59^{\circ}27'30''$, Long. $108^{\circ}23'30''$. Collections are from a long narrow point which forms the inside curve of the "Hook".

Five miles east of Poplar Point: Lat. $59^{\circ}29'45''$, Long. $107^{\circ}41'$.

Wolverine Point: Lat. $59^{\circ}9'$, Long. $108^{\circ}25'$. See map for details of localities.

William Point: Lat. $59^{\circ}7'30''$, Long. $109^{\circ}19'$. See map for details.

Two miles west of Ennuyouse Creek: Lat. $59^{\circ}3'$, Long. $109^{\circ}34'$. See map for details.

Lake Athabaska to Great Slave Lake

East shore of Lake Mamawi: Lat. $58^{\circ}35'$, Long. $111^{\circ}22'$. Collections from delta sloughs and from granite knolls.

Hay (Prairie) River: Lat. $58^{\circ}37'$, Long. $111^{\circ}44'$. A short, sluggish waterway between Lakes Claire and Mamawi.

Delta of Peace River: Most of the collections are from the Quatre Fourches River, a short stream flowing between Peace River and Lakes Athabaska and Mamawi. Near the Peace its banks are well wooded but near the lakes it flows through delta flats. A few collections so cited are from the Scow Channel, a northern branch of the Peace where it enters the Slave. For details of this and the following see citations in the writer's "*Botanical Investigations in Wood Buffalo Park*."

Upper Slave River lowland: Collections are mostly from three localities, near the point where the 30th surveyed base line crosses the river (Lat. $59^{\circ}7'$, Long. $111^{\circ}27'$), the Murdock Creek district (Lat. $59^{\circ}14'$, Long. $111^{\circ}34'$), and the Government Hay Camp district (Lat. $59^{\circ}31'$, Long. $111^{\circ}28'$). They are mostly from the river lowlands and occasional granite knolls.

Fort Smith: Lat. $60^{\circ}00'30''$, Long. $111^{\circ}53'$. Collections are from the bank of the River, from the village itself, and from nearby sloughs and upland woods. A few are from the Portage Road near its eastern end, and from the vicinity of upper Smith Rapids near the town of Fitzgerald.

Lower Slave River: Most of the collections noted thus are from the banks of the river not far below Grande Detour, about 60 miles below Fort Smith.

Hill Island Lake: Lat. $60^{\circ}30'$, Long. $109^{\circ}45'$.

Tazin Lake: Lat. $59^{\circ}50'$, Long. $109^{\circ}20'$. Both this and the preceding are on the canoe route between the north shore of Lake Athabaska and the south shore of Great Slave Lake.

Great Slave Lake

Resolution: Lat. $61^{\circ}10'$, Long. $113^{\circ}40'$.

Mouth of Taltson River: Lat. $61^{\circ}25'$, Long. $112^{\circ}45'$.

Caribou Island: Lat. $61^{\circ}55'$, Long. $113^{\circ}10'$.

Keith Island: Lat. $62^{\circ}3'$, Long. $111^{\circ}57'$. Collections are from a small sandy cove on the western side of the island.

Taltheilei Narrows: Lat. $62^{\circ}42'$, Long. $111^{\circ}25'$. Collections here are not from the Narrows proper, but from a point on the north shore of the lake about 8 miles to the northeast.

North shore of McLeod Bay: Collections cited thus are mostly from the mouth of Mountain River.

Fairchild Point: Lat. $62^{\circ}43'$, Long. $109^{\circ}10'$. See map for details. Most of the collections are from the outer half of the long peninsula.

Maujelly Point: A long peninsula from the south shore of McLeod Bay which, with Fairchild Point, cuts off Charlton Bay.

Pike's Portage: See map for details.

Fort Reliance: Lat. $62^{\circ}47'$, Long. $108^{\circ}55'$. Site of Back's old fort (1833-5).

Yellowknife Bay: Lat. $62^{\circ}25'$, Long. $114^{\circ}18'$. Most of the collections are from the vicinity of the trading post, near the position given above.

Old Fort Rae: Lat. $62^{\circ}38'$, Long. $115^{\circ}48'$.

Fort Rae: Lat. $62^{\circ}50'$, Long. $116^{\circ}4'$.

Moraine Point: On the north shore of the western arm of the Lake, between Jones and Gypsum Points.

Slave Point: Lat. $61^{\circ}12'$, Long. $115^{\circ}57'$.

Windy Point: Lat. $61^{\circ}18'$, Long. $115^{\circ}50'$. This and the preceding are on the north shore of the west arm.

Artillery Lake: Lat. $63^{\circ}5'$, Long. $107^{\circ}50'$. The arctic margin of the timbered country crosses this lake about midway, and the position given above is approximately that of "Last Woods" on the east shore, from which many collections have come.

Casba Lake: Lat. $63^{\circ}36'$, Long. $107^{\circ}25'$. This is *Ptarmigan Lake* of recent maps.

Terms of frequency, such as *rare*, *occasional*, *frequent*, or *abundant* are self explanatory. Further notes upon the relative abundance of species and their positions in the various plant associations will be found in the subsequent paper. Most of the terms describing habitats also need no explanation except in one or two cases. A *muskeg* is an undrained depression whose cover consists mainly of mosses, the commonest of which are species of *Sphagnum*. In contrast to this the terms *slough* or *wet meadow* have been used to designate swamps whose cover is of grasses and sedges. In describing the ranges of plants, their positions have been approximated with relation to the major vegetation boundaries, as far as the latter are understood at present. One of these is the northern boundary of the timbered country, which passes through our region in the northeast. Another is the contact zone between the pre-Cambrian and Paleozoic rocks. This is one of the most conspicuous of the floral boundaries, and follows the Slave River valley northward to Great Slave Lake. The contact crosses the latter and is covered northward by the north arm of the lake itself. Another less conspicuous botanical transition area is in the lower Athabaska River region, where the valley leaves the highlands of Cretaceous sediments which border the Athabaska and Clearwater Rivers about McMurray. In summarizing the broader Mackenzie basin ranges of the species, a collector's name in italics has been added wherever the writer has seen a specimen. Otherwise the terms "recorded by" or "noted by" are used.

The order of the citation of specimens is that given in the above list of localities, and follows a geographic sequence. Where numbers are available they have been used, and if the record is one attributed to an earlier collector, the name is inserted in italics. Numbers without such names are the writer's own, except in the case of nos. 4395–4703, inc., which bear the name also of E. C. Abbe, who served as field assistant in the summer of 1932. The writer's collections from the Athabaska —

Great Slave Lake region are as yet undistributed, but are available for study at the Gray Herbarium or at the herbarium of the Arnold Arboretum. The following is a list of herbaria from which citations have been made in the list:

A — Arnold Arboretum.

G — Gray Herbarium, Harvard University.

N — New York Botanical Garden.

O — National Museum of Canada, Ottawa.

W — U. S. National Herbarium.

Ball — Private Herbarium of Carleton R. Ball.

In the selection of names the author has tried to adhere to the International Rules of Botanical Nomenclature. The order and definition of families is that of Engler and Gilg's "Syllabus der Pflanzenfamilien" (9th and 10th editions), and the order of genera follows the same work except in a few cases such as the Gramineae and Cruciferae. Synonyms have been inserted wherever they are essential for comparison with floristic works of reference touching the region. Owing to the fact that many years have elapsed since a comprehensive flora of any part of north temperate or arctic America has been published, it has been necessary to go to the files of periodical literature for recent revisions of a great many genera and species. References to this body of literature have been included wherever they have seemed pertinent.

A few species the knowledge of whose occurrence in our area rests upon unverified statement, have been grouped in a separate list which will appear at the end of the paper.

The catalogue must not be regarded as complete in any sense. It has been the writer's purpose simply to bring together in one place as many of the scattered records as possible, so as to make the future direction of botanical work in the Mackenzie basin more intelligent.

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The writer is deeply indebted to a great number of persons and institutions for assistance in preparing this catalogue. The summer journeys of 1928, '29 and '30 in the Wood Buffalo Park were financed entirely by the National Museum of Canada, and the same institution has generously assisted later expeditions by the loan of maps and equipment. The journey to the Peace River and Lake Athabaska in 1932 was supported by the Arnold Arboretum and the National Research Council, while that of 1935 to Lake Athabaska was made possible by a generous grant from the Milton Fund for Research, of Harvard University. Most of the study of earlier collections was accomplished with the aid of fellowship grants from the National Research Council. To the herba-

rium staff of the National Museum of Canada, particularly to the late Dr. M. O. Malte, and to the staff of the New York Botanical Garden Herbarium are due especial thanks for assistance in locating specimens and negotiating large loans of material for study. It is impossible to mention individually all the persons whose friendly guidance and assistance in the field have helped to make long trips more comfortable and collecting more efficient. The author wishes to express his gratitude especially to the officers of the Hudson's Bay Company for innumerable kindnesses rendered over and above the expected services for which remuneration was made. In the determination of specimens, the checking of nomenclature, and the study of ranges, Professor M. L. Fernald of the Gray Herbarium has been a constant source of inspiration and assistance. Mr. C. A. Weatherby has very kindly checked over most of the ferns and fern allies, Dr. Ivan M. Johnston the few specimens of Boraginaceae, and Dr. F. W. Pennell of the Academy of Natural Sciences of Philadelphia has gone over most of the Scrophulariaceae. The specimens of *Arabis* have been examined by Dr. Milton Hopkins of the University of Oklahoma, and those of *Eleocharis* by Dr. H. K. Svensen of the Brooklyn Botanic Garden. Professor Alfred Rehder has given many valued suggestions in the identification of ligneous plants. The determinations of the writer's first two seasons' collections of Gramineae and *Carex* were verified by the late authorities in these groups, Dr. A. S. Hitchcock and K. K. Mackenzie, and his early collections of *Equisetum* were checked by Professor J. H. Schaffner of Ohio State University. The writer's wife, Lucy C. Raup, has been his constant and enthusiastic companion throughout the course of the work, sharing the discomforts and satisfactions of wilderness travel, and contributing notably to the scientific results by her collections and studies of the cryptogamic flora.

OPHIOGLOSSACEAE

Botrychium multifidum (Gmel.) Rupr. — *B. matricariaefolium* (Schränk) Spreng. — *B. ternatum* (Thimb.) Sw. var. *rutae-folium* (A. Br.) D. C. Eat. — See Rept. Mich. Acad. Sci. 18: 86 (1916). — Apparently rare, and known from a single locality on the north shore of Lake Athabaska, where it was growing abundantly in sandy thickets and open woods. — Sand Pt., L. Athabaska, nos. 4565, 4649, 4654.

POLYPODIACEAE

Woodsia ilvensis (L.) R. Br. — Common in rock crevices throughout the pre-Cambrian area. — Lake Athabaska: Chipewyan, nos. 4686, 4687, 6050; and *D. G. Revell* [*Moss*, no. 2415(G)]; Shelter Pt., nos. 9, 4434; Sand Pt., nos. 4603, 4611; Charlot Pt., nos. 6097, 6485; W.

shore of Ellis Bay, no. 6109; Cornwall Bay, no. 6455. Granite Hills in Peace R. delta and along upper Slave R., nos. 8, 1450. Great Slave L.: *Howe*, no. 91993(O); near Caribou Isl., *Seton & Preble*, no. 78571-a (O).

Woodsia glabella R. Br. — Apparently confined to moist crevices in dolomitic rocks, mainly in the pre-Cambrian country, where it is common. Plants referred to in Macoun's Catalogue as *Woodsia hyperborea* (*W. alpina*), "Rocks about Fort Chipewyan, Athabaska. (*W. G. Traill*) — northward to the Arctic Circle," may possibly be this species; but the writer has seen no specimen collected by Traill, nor is there any other record for *W. alpina* in the entire Mackenzie basin. — Clearwater R., *J. M. Macoun*, no. 28339(O), and *John Macoun*, no. 28342(O); hills N. of Cornwall Bay, L. Athabaska, nos. 6444, 6498, 6538. Great Slave L.: *R. Bell*, no. 23152(O); Taltheilei Narrows, no. 4; Maufelly Pt., no. 7; Fairchild Pt., nos. 5, 6.

Woodsia oregana D. C. Eat. — Apparently rare, and found thus far only in the Athabaska Lake region where it inhabits moist crevices, chiefly in basic rocks. — Charlot Pt., no. 6434; Cornwall Bay, no. 6435; granite hill in Peace River delta, no. 1453-a.

Woodsia scopulina D. C. Eat. — This record is based upon a single immature specimen collected late in June, 1935, on the north shore of Lake Athabaska. Although somewhat doubtfully determined, due to its fragmentary condition, it bears the characteristic hairs of *W. scopulina*, and is therefore placed here with considerable confidence. — Small island near base of Charlot Pt., no. 6387.

Cystopteris fragilis (L.) Bernh. — *Filix fragilis* (L.) Gilib. — Common in shaded rock crevices, reaching greatest size and abundance in moist ravines. — Clearwater R., *J. M. Macoun*, no. 28471(O). Lake Athabaska: Chipewyan, nos. 4686, 6053; Charlot Pt., nos. 6085, 6234, 6236, 6278; Cornwall Bay, no. 6573. Granite hills in the Peace R. delta, nos. 1453, 4400. Great Slave L.: island in E. arm, no. 3; Taltheilei Narrows, no. 1; Fairchild Pt., no. 2; N. W. shore, *Bedford* (O).

Pteretis nodulosa (Michx.) Nieuwl. — *Onoclea Struthiopteris* of Am. auth., not Hoffm. — *Matteucia Struthiopteris* of Am. auth., not Todaro. — See *Rhod.* 17: 164 (1915). — Common in low woods along the lower Clearwater and Athabaska rivers. — Waterways, no. 1449; Reed's Portage, upper Athabaska delta, no. 1448.

Thelypteris Phegopteris (L.) Slosson. — *Phegopteris polypodioides* Fée. — Known in the Mackenzie basin from a single collection, near the eastern end of Lake Athabaska. — Axis L., *Campbell*, no. 132412(O).

Thelypteris Dryopteris (L.) Slosson — *Phegopteris Dryopteris* (L.) Fée. — Although recorded by Richardson at Great Bear Lake, this species has not since been found north of Lake Athabaska. It inhabits rich woods and damp rock crevices. — Clearwater R., *J. M. Macoun*, no. 2841(O); steep slope back of McMurray, no. 7090; along lower Firebag R., no. 6017. Lake Athabaska: Sand Pt., no. 4483; bank of Archibald R. near its mouth, no. 6759.

Thelypteris Robertiana (Hoffm.) Slosson. — *Phegopteris Robertiana* (Hoffm.) A. Br. — *P. Dryopteris* var. *Robertiana* of Macoun's Cat. — Rare or occasional, and found thus far only on the north shore of Lake Athabaska where it inhabits rather dry rock crevices. — Shelter Pt., no. 16; near Sand Pt., no. 4477; Charlot Pt., nos. 6235, 6295; Cornwall Bay, no. 6568.

Thelypteris fragrans (L.) Nieuwl. — *Dryopteris fragrans* (L.) Schott. — *Aspidium fragrans* (L.) Sw. — Common in dry rock crevices in the pre-Cambrian country, usually in exposed situations. — Lake Athabaska: Chipewyan, nos. 6064, 6075; Shelter Pt., no. 13; near Sand Pt., no. 4534; Charlot Pt., no. 6293; near mouth of Charlot R., no. 6331; N. shore of L. Athabaska, *J. W. Tyrrell*, no. 111918(O). Great Slave L.: *R. Bell*, no. 23154(O); near Caribou Isl., *Seton & Preble*, no. 78571(O); Taltheilei Narrows, no. 14; Fairchild Pt., no. 15. Parry Falls, Lochart R., *J. W. Tyrrell*, no. 23144(O).

Thelypteris spinulosa (O. F. Müll.) Nieuwl. — *Dryopteris spinulosa* (O. F. Müll.) Ktze. — *Aspidium spinulosum* (O. F. Müll.) Sw. — Apparently rare, at least in the northern and central parts of the region, and found in damp thickets. Its most northern recorded station is just north of the height of land between Great Slave and Great Bear Lakes (*Bedford*, O). — Near McMurray, no. 7106; Chipewyan, no. 4689.

Pellaea glabella Mett. ex Kuhn. — See *Am. Fern. Journ.* 7: 3–5, 77–87 (1917); and 11: 39–40 (1921). — Apparently quite rare, and although reported by Richardson as far north as Great Bear Lake (as *Pteris atro-purpurea* in *Fl. Bor.-Am.*), it has never been collected in our region except in the two places cited below. It seems to be confined to limestone or dolomitic rocks. — Clearwater R., *J. M. Macoun*, no. 28389(O) (may possibly be referred to var. *occidentalis* (E. Nels.) Butters [*P. pumila* Rydb.]); crevices in dolomite hill near base of Cornwall Bay, L. Athabaska, no. 6558.

Cryptogramma crispa (L.) R. Br. var. *acrostichoides* (R. Br.) C. B. Clarke. — *C. acrostichoides* R. Br. — See *Rhod.* 37: 238–47 (1935). — Common in dry crevices, chiefly on the granitic and older rocks, and reported northward to Great Bear Lake by Richardson. —

Lake Athabaska: Shelter Pt., nos. 17, 4433; N. shore of Ellis Bay, no. 6144; Cornwall Bay, no. 6432. Granite hill along upper Slave R., no. 1451. Great Slave L., *R. Bell*, no. 23153(O).

***Polypodium virginianum* L.** — See *Rhod.* 24: 125 (1922). — Common in rock crevices throughout the forested part of the region. — Lake Athabaska: Chipewyan, no. 6065-a; Shelter Pt., no. 12; Sand Pt., no. 4612; Charlot Pt., no. 6095; Fishhook Bay, no. 6589; 5 mi. E. of Poplar Pt., no. 6640. Granite hills in the Peace R. delta and along upper Slave R., nos. 10, 1455, 1456. Great Slave L.: *R. Bell*, no. 23151(O); island in E. arm, no. 11; near Caribou Isl., *Seton & Preble*, no. 78572 (O); 50 mi. N. of Resolution, *J. W. Tyrrell*, no. 23145(O); N. shore, *Bedford* (O).

EQUISETACEAE

***Equisetum arvense* L.** — Common in woods and thickets throughout the region, but occupying a great variety of habitats. — Lower Athabaska R.: about 15 mi. below McMurray, no. 61; Calumet, nos. 49-a, 54; along Firebag R. near its mouth, no. 6045. L. Athabaska: Shelter Pt., nos. 50, 51, 52, 53; Charlot Pt., no. 6264; Cornwall Bay, no. 6506; bank of Archibald R. near its mouth, no. 6756; lake shore just W. of Ennuyouse Cr., no. 6940. Peace-Athabaska delta and upper Slave R., nos. 55, 56, 57, 58, 62, 66, 1481, 1488; Ft. Smith, no. 63. Great Slave L.: Resolution, *Kennicott* (N); Fairchild Pt., nos. 48, 65, 67, 68, 69, 70, 71, 72; Yellowknife Bay, no. 64; 12 mi. E. of Moraine Pt., N. W. shore, *Bedford* (O).

***Equisetum pratense* Ehrh.** — Not thus far collected north of the Slave River region and the adjacent Wood Buffalo Park, nor eastward in the pre-Cambrian country. In the poplar and poplar-spruce woods of the river flood plains it forms a dense cover on the forest floor, and its early succulent stages are eaten with apparent relish by grazing stock. — Lower Athabaska R.: about 15 mi. below McMurray, no. 46; Calumet, nos. 41, 42. Peace-Athabaska delta and upper Slave R., nos. 44, 45, 47, 1497; Ft. Smith, no. 43.

***Equisetum sylvaticum* L. var. *pauciramosum* Milde.** — See *Rhod.* 20: 129 (1918). — Common in rich woods northward to Great Bear Lake (*R. Bell*, O), and extending northeastward beyond the limit of trees (*J. W. Tyrrell*, O). — Lake Athabaska: Shelter Pt., nos. 19, 20, 21; near Sand Pt., no. 4577; Camsell Portage, no. 6202; near Wabba L., N. of Cornwall Bay, no. 6500; Cornwall Bay, no. 6505; 5 mi. E. of Poplar Pt., no. 6698. Great Slave L.: Resolution, *Kennicott* (N); Taltheilei Narrows, no. 18; N. W. shore, *Bedford* (O).

***Equisetum palustre* L.** — Common on low mud bars along the

main rivers. Although Richardson (Fl. Bor.-Am.) reported it as far north as the "shores of the Arctic Sea," the writer has seen no specimens from beyond the Slave River nor from the pre-Cambrian country to the eastward. — Upper Slave R., no. 1470; lower Slave R., below Grande Detour, no. 40.

Equisetum limosum L. — *E. fluviatile* L. — See Rhod. 23: 43 (1921). — Abundant on the slough margins of lakes and ponds, and on the muddy shores of river flood plains. Not thus far reported north of Great Slave Lake nor beyond the limit of trees. — Calumet, lower Athabaska R., no. 32; lower delta of Athabaska R., no. 33. L. Athabaska: Shelter Pt., no. 34; 5 mi. E. of Poplar Pt., no. 6680; William Pt., no. 6848; about 2 mi. W. of Ennuyeuse Cr., nos. 6967, 6988. Peace R. delta and upper Slave R., nos. 1473, 1478, 1479; Ft. Smith, no. 31; lower Slave R. and delta, nos. 25, 26. Great Slave L.: Fairchild Pt., nos. 27, 28, 30; Yellowknife Bay, no. 29; N. W. shore, *Bedford* (O).

Equisetum prealtum Raf. — *E. robustum* A. Br. — *E. hyemale* L. var. *robustum* (A. Br.) A. A. Eat. — *E. hyemale* L. var. *affine* (Engelm.) A. A. Eat. — Common on the higher parts of mud bars along the main rivers. Not thus far reported north of the Slave River, nor eastward in the pre-Cambrian country. — Athabaska Landing district, *Brinkman*, no. 4061(N); lower Peace R. near its entrance into the Slave, no. 74; upper Slave R., no. 73.

Equisetum scirpoides Michx. — Abundant in timbered muskegs about Great Slave Lake and in the Wood Buffalo Park, but apparently not common farther south. — Charlot Pt., L. Athabaska, no. 6129. Great Slave L.: Fairchild Pt., nos. 22, 24; Yellowknife Bay, no. 23.

Equisetum variegatum Schleich. — Although described as frequent northward to the Arctic in Fl. Bor.-Am., this species appears to be quite rare in that part of the Mackenzie basin south of Great Slave Lake. — Great Slave L.: Taltheilei Narrows, no. 37; Fairchild Pt., nos. 35, 36, 38, 39.

LYCOPODIACEAE

Lycopodium Selago L. — Common in rock crevices about Great Slave Lake, but apparently only occasional in the Athabaska Lake district. Not found thus far in the Paleozoic districts. — Lake Athabaska: Sand Pt., no. 4591; west shore of Ellis Bay, no. 6367; muskeg margin of small pond 5 mi. S. E. of Wolverine Pt., no. 6821. Great Slave L.: *R. Bell*, no. 23150(O); near Caribou Isl., *Seton & Preble*, no. 78573(O); Taltheilei Narrows, no. 86; Maufelly Pt., no. 87.

Lycopodium annotinum L. — This species and its two varieties are common or occasional in woods and thickets northward to Great

Bear Lake. — Lake Athabaska: N. shore, *J. W. Tyrrell*, no. 28285(O); Shelter Pt., nos. 78, 79; Sandy Pt., no. 4513; mouth of Charlot R., no. 6311; Cornwall Bay, no. 6597; 5 mi. E. of Poplar Pt., no. 6673; 2 mi. W. of Ennuyeuse Cr., no. 6938. Great Slave L.: Taltheilei Narrows, no. 80; Pike's Portage, *J. W. Tyrrell*, no. 23146(O).

***Lycopodium annotinum* L. var. *pungens* Desv.** — Shelter Pt., L. Athabaska, no. 75. Great Slave L.: Taltheilei Narrows, no. 76; N. W. shore, *Bedford* (O).

***Lycopodium annotinum* L. var. *acrifolium* Fern.** — See *Rhod.* 17: 123 (1915). — Lake Athabaska: Shelter Pt., no. 77; Sand Pt., no. 4590; Camsell Portage, nos. 6187, 6207; Cornwall Bay, no. 6431; sandy woods about 4 mi. S. E. of Wolverine Pt., nos. 6778, 6782.

***Lycopodium clavatum* L. var. *monostachyon* Grev. & Hook.** — See *Rhod.* 12: 50 (1910). — Apparently rare in the Mackenzie basin, and collected thus far only on Lake Athabaska. — Shelter Pt., no. 81; Sand Pt., no. 4589; mouth of Archibald R., no. 6755.

***Lycopodium clavatum* L. var. *megastachyon* Fern. & Bissell.** — See *Rhod.* 12: 50 (1910). — Apparently quite rare, and known in this region from a single collection. It has been collected also in the Lesser Slave Lake district (*Brinkman*, N) but nowhere else in the Mackenzie basin. — Rocky lake shore at Shelter Pt., L. Athabaska, no. 82.

***Lycopodium obscurum* L. var. *dendroideum* (Michx.) D. C. Eat.** — See *Rhod.* 23: 188 (1921). — Rare or occasional in the northern part of the Mackenzie basin, but common in the sandy woodlands about Lake Athabaska, particularly on the south side. It has not been collected on Great Slave Lake, but has been found near Ft. Norman, on the Mackenzie River (*Miss E. Taylor*, O). — McMurray, no. 7120. Lake Athabaska: near Sand Pt., no. 4592; Camsell Portage, no. 6188; N. of Cornwall Bay, no. 6512; 5 mi. E. of Poplar Pt., no. 6646; point about 4 mi. E. of Wolverine Pt., no. 6806; William Pt., no. 6899.

***Lycopodium sabinaefolium* Willd. var. *sitchense* (Rupr.) Fern.** — *L. sitchense* Rupr. — See *Rhod.* 25: 166 (1923). — Apparently rare, and known only from the following two localities. The only other record for the Mackenzie basin is from Lesser Slave Lake (*Brinkman*, N). — Portage la Loche (Methye Portage), *John Macoun*, no. 28199(O) (under *L. sabinaefolium* in Macoun's Cat.); sandy woods along William R. near its entrance to L. Athabaska, no. 6898.

***Lycopodium complanatum* L.** — Common in dry woods northward to Great Bear Lake. A form with very short peduncles (1 cm. or less) is common about Lake Athabaska. It is represented by nos. 6399, 6647, 6803. — Lake Athabaska: Shelter Pt., nos. 84, 85; Sand Pt., no.

4588; Charlot Pt., no. 6399; Cornwall Bay, no. 6592; 5 mi. E. of Poplar Pt., no. 6647; point about 4 mi. E. of Wolverine Pt., no. 6803. Great Slave L.: Taltheilei Narrows, no. 83; Ft. Reliance, *J. W. Tyrrell*, no. 23147(O).

Lycopodium tristachyum Pursh. — Occasional in sandy thickets and open woods about Lake Athabaska. — Sand Pt., no. 4587; Camsell Portage, no. 6211; just E. of Wolverine Pt., no. 6797.

SELAGINELLACEAE

Selaginella selaginoides (L.) Link. — Known thus far in the Mackenzie basin east of the mountains only from the following station. — Wet mossy crevices on shore of L. Athabaska near Sand Pt., no. 4629.

Selaginella rupestris (L.) Spring. — Common on exposed rocky and sandy hillsides about Lake Athabaska, but unknown elsewhere in the Mackenzie basin. — Shelter Pt., no. 4451; Sand Pt., no. 4608; Charlot Pt., nos. 6305, 6411; Cornwall Bay, no. 6607; near mouth of Ennuyeuse Cr., no. 6929.

ISOËTACEAE

Isoëtes Braunii Dur. — See Ann. Mo. Bot. Gard. 9: 156–73 (1922). — Apparently quite rare, and known in the Mackenzie basin from a single collection. — In shallow water on the sandy-gravelly shore of a small lake near Sand Pt., L. Athabaska, no. 4617.

PINACEAE

Picea glauca (Moench) Voss. — *P. canadensis* of most Am. auth. — *P. alba* of Macoun's Cat. — *Pinus alba* of Fl. Bor.-Am. — See Rhod. 17: 60–2 (1915). — The predominating forest tree throughout most of the Mackenzie basin, extending nearly to the arctic coast and far out into the Barren Lands in sheltered places. It reaches its best development on the banks of the main rivers and on the better-drained soils of the uplands, particularly in the Paleozoic and younger regions. 75-ft. trees, 2 feet in diameter at the base, are common in the lowlands, while larger ones, 3 ft. or more in diameter, occur in localized areas. In exposed places, particularly eastward in the pre-Cambrian country, the trees become much dwarfed, with gnarled and twisted trunks and branches. On sand plains about Great Slave Lake the spruce forms an open park-like forest of comparatively small but straight trees, while on Lake Athabaska its place is largely taken by *Pinus Banksiana* in such situations. — Calumet, lower Athabaska R., nos. 97, 98; Lake Athabaska: N. shore, *J. W. Tyrrell*, no. 25039(O); Shelter Pt., no. 99; near Sand Pt., nos. 4541, 4662; Charlot Pt., no. 6401; 2 mi. W. of

Ennuyeuse Cr., no. 6954. Peace R. delta and upper Slave R., nos. 102, 103, 1526; Ft. Smith, no. 100. Great Slave L.: Taltheilei Narrows, no. 104; Fairchild Pt., nos. 101, 105, 106. Artillery L., *J. W. Tyrrell*, no. 23134(O).

Picea mariana (Mill.) B. S. P. — *Pinus nigra* of Fl. Bor.-Am. — *Picea nigra* of Macoun's Cat. — The most abundant tree in the muskeg timber of the central part of the Mackenzie basin. It is rarely observed more than 5 or 6 inches in diameter, and is usually much smaller than this. In the pre-Cambrian region it is sometimes associated with white birch and jack pine on sand plains. Richardson placed its northern boundary at lat. 65°, but the writer has seen no specimens from north of Great Slave Lake. Preble reported it on the north slopes of the Nahanni Mountains, west of the Mackenzie. — Calumet, lower Athabaska R., no. 95. Lake Athabaska: N. shore, *J. W. Tyrrell*, no. 25074(O); Shelter Pt., nos. 91, 92, 93, 94; near Sand Pt., no. 4664; Charlot Pt., no. 6400; about 2 mi. W. of Ennuyeuse Cr., no. 7008. Fairchild Pt., Great Slave L., no. 96.

Abies balsamea (L.) Mill. — This species is common only in the southern and southeastern parts of the Mackenzie basin, and its northern boundary is still conjectural. Richardson (Bot. App. to Franklin's first exped.) states that he found it at latitude 62°, but is not specific as to locality. Dr. Charles Camsell, exploring for the Canadian Geological Survey west of Fort Smith in 1902, reported finding the balsam fir in the gorge of the Little Buffalo River (C. G. S. Ann. Rept. 15: 159A), but this has not been verified. The farthest north from which the writer has seen specimens is the delta of the Athabaska River, and this is consistent also with the findings of Preble (N. Am. Fauna, No. 27, p. 518). — Reed's Portage, Athabaska R. delta, no. 1521.

Larix laricina (DuRoi) Koch. — *L. americana* Michx. — This species probably extends through the entire timbered part of the Mackenzie basin, although actual specimens of it from the far north are rare in herbaria. It is common in muskegs in the Athabaska — Great Slave Lake region, but it nearly always plays a secondary part in the timber, and rarely exceeds 8–10 inches in diameter. — Lake Athabaska: Shelter Pt., nos. 88, 89; near Sand Pt., no. 4663; mouth of Charlot R., no. 6317; about 2 mi. W. of Ennuyeuse Cr., no. 7007. Great Slave L.: Taltheilei Narrows, no. 90; N. W. shore, *Bedford* (O).

Pinus Banksiana Lamb. — *P. divaricata* of auth. — Abundant on dry sand plains and on sandy and rocky hills northward through the central part of the timbered country. About Lake Athabaska and west of the Slave River it is the characteristic species of large tracts of park-

like timber in which there is but little undergrowth and a very sparse ground cover. Richardson reported it on the sandy banks of the Mackenzie beyond lat. 64°. On the eastern arm of Great Slave Lake it is displaced on the sand plains by white spruce, *Picea glauca*, but occurs in scattered localities nearly to the limit of trees. — Calumet, lower Athabaska R., no. 107. Lake Athabaska: Goose Isl., *Laing*, no. 22(N); Shelter Pt., nos. 108, 109; Sand Pt., no. 4653; west shore of Ellis Bay, no. 6169; 2 mi. W. of Ennuyeuse Cr., no. 6953. Great Slave L.: Pike's Portage, *J. W. Tyrrell*, no. 23135(O); N. W. shore, *Bedford* (O).

***Juniperus communis* L. var. *montana* Ait. — *J. sibirica* Burgsd.** — Common throughout the region on dry rocky and sandy plains and ridges. — Lake Athabaska: Shelter Pt., nos. 110, 111, 112, 113; Sand Pt., no. 4661; Charlot Pt., no. 6144; Cornwall Bay, no. 6602; sandy bank of Archibald R., near its mouth, no. 6734; 2 mi. W. of Ennuyeuse Cr., no. 6932. Granite hill along upper Slave R., no. 1516. Great Slave L.: Taltheilei Narrows, no. 117; Fairchild Pt., nos. 114, 116; Ft. Reliance, no. 115; S. W. and N. shores, *Howe*, no. 91992(O).

***Juniperus horizontalis* Moench. — *Sabina horizontalis* (Moench.) Rydb.** — Common in dry sandy and rocky places throughout the timbered country northward at least to the Great Slave Lake region. — Lake Athabaska: Chipewyan, *Laing*, no. 23(N), and *J. W. Tyrrell*, no. 24952(O); Shelter Pt., nos. 119, 120; granite island about 6 mi. E. of Chipewyan, no. 4671; Charlot Pt., no. 6141; Cornwall Bay, no. 6603. Ft. Smith, no. 121. Great Slave L.: Caribou Isl., *Seton & Preble*, no. 78568(O); Taltheilei Narrows, no. 125; Fairchild Pt., nos. 122, 123, 124.

TYPHACEAE

***Typha latifolia* L.** — Richardson reported this species as far north as Ft. Franklin (Fl. Bor.-Am.), but the writer has seen no specimens from beyond the Wood Buffalo Park region, where it is common on the shores of lakes and ponds. Also it has not been noted anywhere in the pre-Cambrian region to the eastward. — Lower delta of Athabaska R., nos. 126, 1530; upper Slave R. lowlands, no. 1533.

SPARGANIACEAE

***Sparganium eurycarpum* Engelm.** — See Rhod. 24: 26 (1922). — Common at the margins of ponds and slow streams in the Athabaska-Peace delta, but not elsewhere reported in the Mackenzie basin. — Lower delta of Athabaska R. (Mamawi Cr.), no. 1540; upper Slave R. lowlands, nos. 128, 1541.

***Sparganium multipedunculatum* (Morong) Rydb.** — See Rhod. 27: 190 (1925). — The commonest bur-reed in the central part of

forested region, but scarcely extending eastward into the pre-Cambrian country. It is most abundant at the margins of lakes, sloughs, and slow streams, and has been noted as far northward as Ft. Franklin (*Richardson*, N). — Lower delta of Athabaska R. (Mamawi Cr.), no. 1535; Chipewyan, no. 4693; upper Slave R. lowlands, no. 1536. Great Slave L.: Buffalo R., *Richardson* (G) (under *S. simplex* in Fl. Bor.-Am. and Macoun's Cat.); N. W. shore, *Bedford* (O).

Sparganium fluctuans (Morong) B. L. Robinson. — Known in the Mackenzie basin from only two localities about Lake Athabaska. — Small pond at Shelter Pt., no. 127; small lagoon near shore of main lake about 2 mi. west of Ennuyeuse Cr., no. 6992.

Sparganium angustifolium Michx. — See *Rhod.* 24: 26 (1922). — Locally abundant in ponds and slow streams, and not yet noted north of Great Slave Lake. — Lake Athabaska: pond near base of Cornwall Bay, no. 6616; pond about 2 mi. W. of Ennuyeuse Cr., no. 6990. Upper Slave R. lowland, no. 1544. Great Slave L.: Fairchild Pt., no. 130; Ft. Rae, *Bedford* (O).

Sparganium minimum Fries. — Common at muskeg or pond margins about Lake Athabaska, but very little collected elsewhere in the Mackenzie basin, though it is probably widespread. — Lake Athabaska: Shelter Pt., no. 4423; small pond near base of Cornwall Bay, no. 6615; William Pt., nos. 6843, 6865; small lagoon about 2 mi. W. of Ennuyeuse Cr., no. 6997.

POTAMOGETONACEAE

Potamogeton tenuifolius Raf. — *P. alpinus* of Am. auth. — See *Rhod.* 32: 76–83 (1930) and 33: 209–11 (1931). — Common in ponds and slow streams about Lake Athabaska, but very little collected elsewhere in the Mackenzie basin, though it is probably widespread. — Lake Athabaska: small ponds near base of Cornwall Bay, nos. 6498-a, 6618, 6621, 6622; Archibald R. near its mouth, nos. 6741, 6742; no. 6742 was growing in more rapid water, and has the form of var. *subellipticus* (Fern.) Fern.

Potamogeton gramineus L. var. *graminifolius* Fries. — *P. heterophyllus* of most recent Am. auth., not Schreb. — See *Rhod.* 23: 189 (1921). — Apparently common in shallow lakes and slough ponds throughout the forested region northward to Great Bear Lake (*Porsild*, G). It is abundant in the lower deltas of the Athabaska and Peace Rivers. — Lake Athabaska: Shelter Pt., no. 136; near Sand Pt., no. 4614; small pond about 5 mi. S. E. of Wolverine Pt., no. 6823; William Pt., no. 6849; small lagoon about 2 mi. W. of Ennuyeuse Cr., no. 7002. Lake Mamawi, no. 1548; upper Slave R. lowlands, nos. 135, 1546. Northwest shore of Great Slave L., *Bedford* (O).

Potamogeton Richardsonii (A. Benn.) Rydb. — This is probably the commonest pondweed in the region, and is abundant in shallow lakes and slough ponds throughout the forested parts north to Great Bear Lake (*Porsild*, G). It is associated with *P. vaginatus* in the great masses of weed which clog the shallow expanses of Lakes Claire and Mamawi, and the western part of Lake Athabaska. — Methye Portage, *J. M. Macoun*, no. 3047(O) (*P. perfoliatus* var. *Richardsonii* of Macoun's Cat.). Lake Athabaska: about 6 mi. E. of Chipewyan, no. 4666; Charlot R. near its mouth, no. 6352; small ponds near base of Cornwall Bay, nos. 6497-a. no. 6617. Lake Mamawi, no. 1551; upper Slave R. lowland, nos. 134, 1556. Great Slave L.: N. W. shore, *Bedford* (O); Ft. Rae, *Bedford* (O).

Potamogeton praelongus Wulf. — Probably common throughout the forested region, but very little collected. It inhabits the deeper water off-shore in relatively shallow lakes, and has been found in Arctic Mackenzie by the Porsild brothers. It is apparently common in the Wood Buffalo Park. — Yellowknife Bay, Great Slave L., no. 133.

Potamogeton zosteriformis Fern. — See Mem. Gray Hb. 3: 36–40 (1932). — Found in the Mackenzie basin thus far only in the Wood Buffalo Park, where it grows in shallow, marshy lakes both on the upland and the Slave River lowland. — Slave River lowland (Murdoch Cr.), no. 1565.

Potamogeton foliosus Raf. var. **macellus** Fern. — See Mem. Gray Hb. 3: 46–51 (1932). — Known in this region in the Slave River area, and noted also farther west in the Wood Buffalo Park and southward. It grows in shallow lakes and ponds. — Upper Slave R. lowlands, no. 132.

Potamogeton Friesii Rupr. — Probably common in shallow lakes and slough ponds though very little collected, and known northward to Great Bear Lake (*Porsild*, G). In our region it is not recorded east of the Slave River district. — Upper Slave R. lowlands (Murdoch Cr. district), no. 1564.

Potamogeton obtusifolius Mert. & Koch. — Known from a single collection near the north shore of Lake Athabaska, and found there only in sterile condition. — Small pond near base of Cornwall Bay, no. 6632.

Potamogeton pusillus L. var. **polyphyllus** Morong. — Collected thus far only once in the Mackenzie basin, in the Athabaska delta. — Lower Athabaska R. delta (Mamawi Cr.), no. 1569.

Potamogeton pusillus L. var. **mucronatus** (Fieber) Graebn. — Known in the Mackenzie basin only from the country about Lake Atha-

baska, where it inhabits streams and ponds. — Small pond near base of Cornwall Bay, no. 6633; Archibald R. near its mouth, no. 6751.

Potamogeton filiformis Pers. var. **borealis** (Raf.) St. John. — See Rhod. 18: 134 (1916). — Probably common throughout, though not much collected in the pre-Cambrian regions. It is most abundant on the sandy bottoms of shallow lake margins. — Near Sand Pt., L. Athabaska, nos. 4615, 4616. Great Slave L.: Fairchild Pt., no. 131; N. W. shore, *Bedford* (O).

Potamogeton vaginatus Turcz. — See Rhod. 18: 131 (1916) and 20: 191 (1918). — Although very little collected, this species shows a wide range northward to Great Bear Lake (*Porsild*, G). It has not been found eastward in the pre-Cambrian region about Athabaska and Great Slave Lakes, but is abundant in the shallow water of the Athabaska-Peace delta where, with *P. Richardsonii*, it forms most of the large patches of weed. — Lake Mamawi, no. 1549.

Potamogeton pectinatus L. — Probably common, at least south of Great Slave Lake, in shallow lakes which have sand or gravel bottoms. — Lake Athabaska: about 6 mi. E. of Chipewyan, no. 4667; small pond near base of Cornwall Bay, nos. 6619, 6634.

SCHEUCHZERIACEAE

Triglochin maritima L. — Common in semi-saline muskegs, sloughs, and wet prairies northward through the Paleozoic and younger country to the basin of Great Bear Lake (*Bedford*, O), and occasional eastward in the pre-Cambrian. In the latter it appears to prefer areas of dolomitic rocks, but also occurs in the sandy country south of Lake Athabaska. — Lake Athabaska: near mouth of Charlot R., no. 6343; about 3 mi. W. of Ennuyeuse Cr., no. 6973. Upper Slave R. lowland, no. 1586. Great Slave L.: Keith Isl., no. 137; Fairchild Pt., nos. 138, 139.

Triglochin palustris L. — Known in the pre-Cambrian region only on Great Slave Lake, but occasional in the Wood Buffalo Park. — Keith Isl., eastern arm of Great Slave L., no. 140.

Scheuchzeria palustris L. — See Rhod. 25: 177-9 (1923). — Known thus far in the Mackenzie basin only from shallow pond margins on the south side of Lake Athabaska, where it is abundant. — William Pt., no. 6868; about 3 mi. W. of Ennuyeuse Cr., no. 6962.

ALISMACEAE

Sagittaria cuneata Sheldon. — *S. arifolia* Nutt. — Common at the margins of ponds and slow streams in the southern part of the Mackenzie basin, and extending to Great Slave Lake in the Paleozoic

country. It was noted by Harper east of the mouth of the Taltson River. — Lower delta of Athabaska R., nos. 393, 1587; upper Slave R. lowland, nos. 1589, 1591; N. W. shore of Great Slave L., *Bedford* (O).

***Alisma Plantago-aquatica* L. subsp. *brevipes* (Greene) Samuels.** — See *Arkiv för Botanik*, 24, 7:19–21 (1932). — Known in this region only in a damp slough at Chipewyan. It also occurs in the Lesser Slave Lake region (*Brinkman*, N). — Chipewyan, no. 4692.

GRAMINEAE

***Bromus ciliatus* L.** — Common in the Paleozoic country northward to the lower Mackenzie, in prairies and other open ground, but not found thus far in the pre-Cambrian regions. — Lower Athabaska R., *Kennicott* (N); McMurray, no. 7101; Ft. Resolution, *Kennicott* (N).

***Bromus Pumpellianus* Scribn.** — Abundant on the sandy beaches and dunes about Lake Athabaska, and at least occasional northward to Great Bear Lake and the Arctic coast (*Richardson*, G, N). It is also widespread in the Wood Buffalo Park and southwestward. — Lake Athabaska: *Laing*, no. 223 (G); Shelter Pt., nos. 205, 206; Sand Pt., no. 4571; 2 mi. E. of Wolverine Pt., no. 6721; shifting sand dunes just E. of Ennuyeuse Cr., no. 6911 (form with very hirsute sheaths). Ft. Smith, no. 204.

***Festuca brachyphylla* Schultes.** — See *Rhod.* 37: 250–2 (1935). — An arctic and alpine species known in this region only on the north shore of Lake Athabaska, where it is found in rock crevices. — Small island about 2 mi. E. of Crackingstone Pt., no. 6423.

***Festuca rubra* L.** — See *Rhod.* 35: 132–5 (1933). — Apparently occasional in the sandy country south of Lake Athabaska, but not known elsewhere in the Mackenzie basin except at Great Bear Lake (*J. M. Bell*, O). — Lake Athabaska: lake shore about 2 mi. E. of Wolverine Pt., no. 6723-a; shifting sand dunes 5 mi. S. of William Pt., no. 6905; sand dunes 2 mi. W. of Ennuyeuse Cr., no. 6941-a.

***Festuca rubra* L. var. *arenaria* (Osbeck) Fries.** — See *Rhod.* 35: 132–5 (1933). — Like the last, this is abundant on sand beaches and dunes about Lake Athabaska, and recurs at Great Bear Lake and on the Arctic coast (*Richardson*, G). Of the following specimens, nos. 6894 and 6900 represent a proliferous form of var. *arenaria*. — Shelter Pt., nos. 171, 4432; Sand Pt., no. 4573; lake shore about 2 mi. E. of Wolverine Pt., nos. 6713, 6723; shifting dunes 5 mi. S. of William Pt., no. 6894; beach at William Pt., no. 6900; sand dunes 2 mi. W. of Ennuyeuse Cr., no. 6941.

***Festuca saximontana* Rydb.** — See *Rhod.* 37: 250–2 (1935). — Common on dry prairies, ridges and beaches northward to Great Bear

Lake (*Richardson*, G. N). — Lake Athabaska: Shelter Pt., nos. 165, 166, 167; Sand Pt., no. 4498; Charlot Pt., nos. 6100, 6257, 6391; N. shore of Ellis Bay, nos. 6117, 6118; sandy beach on main lake shore west of Ellis Bay, no. 6271; rocky point at N. W. entrance to Black Bay, no. 6415; near Wabba L., N. of Cornwall Bay, no. 6467; Cornwall Bay, nos. 6508, 6523, 6544, 6611; 5 mi. E. of Poplar Pt., nos. 6648, 6654; sand ridges about 4 mi. S. E. of Wolverine Pt., no. 6789; gravel dunes just E. of Ennuyeuse Cr., no. 6923; 2 mi. W. of Ennuyeuse Cr., nos. 6939, 6983. East shore of L. Mamawi, no. 1669; Ft. Smith, no. 168; Ft. Reliance, Great Slave L., nos. 169, 170.

Fluminia festucacea (Willd.) Hitchc. — *Scolochloa festucacea* (Willd.) Link. — *Festuca borealis* Mert. & Koch. — Common at lake margins and in wet meadows northward in the Paleozoic and younger country at least to the Wood Buffalo Park, but not known eastward of the great river lowlands. — Lower Athabaska R. delta (Mamawi Cr.), no. 1601; E. shore of L. Mamawi, nos. 1600, 4418; upper Slave R. lowlands, nos. 1599, 1604.

Glyceria striata (Lam.) Hitch. var. **striata** (Scribn.) Fern. — *Panicularia nervata* (Willd.) Ktze. var. *striata* Scribn. — *P. rigida* (Nash) Rydb. — See Proc. Biol. Soc. Wash. 41: 157 (1928) and Rhod. 31: 47 (1929). — Not known north of the Athabaska region, where it grows in damp woods. The specimens from Reed's Portage are very mature, and may represent the species rather than the variety. They were so cited in the writer's *Bot. Investigations in the Wood Buffalo Park*. — Upper Athabaska delta (Reed's Portage), no. 1620; thicket near base of Cornwall Bay, L. Athabaska, no. 6503.

Glyceria grandis Wats. — *Panicularia grandis* Nash. — Common in wet meadows of the great river lowlands north to Great Slave Lake. — Upper Slave R. lowlands, nos. 1610, 1616; Resolution, *Kennicott* (N).

Glyceria pulchella (Nash) K. Sch. — *Panicularia pulchella* Nash. — Common in the wetter parts of sloughs northward to Lake Athabaska and the Wood Buffalo Park. — Lower delta of Athabaska R., no. 200. Lake Athabaska: Shelter Pt., no. 201; 5 mi. E. of Poplar Pt., no. 6675. Upper Slave R. lowland, no. 1611.

Glyceria borealis (Nash) Batchelder. — *Panicularia borealis* Nash. — Found occasionally in wet sloughs in the central parts of the Mackenzie basin, and probably northward in the forested areas. — Lower delta of Athabaska R., no. 202. Lake Athabaska: Shelter Pt., no. 203; 2 mi. W. of Ennuyeuse Cr., no. 6995. Upper Slave R. lowland, no. 1618.

Puccinellia Nuttalliana (Nutt.) Wats. & Coult. — *P. airoides*

(Schultes) Hitchc. — Probably common throughout the forested region in semi-saline situations, but not known eastward in the pre-Cambrian region. — Lower delta of Athabaska R., no. 199. Great Slave L.: *Richardson* (G) (*Poa airoides* in Fl. Bor.-Am., and *Glyceria airoides* in Macoun's Cat.); S. W. and N. shores, *Howe*, no. 91994(O).

***Poa alpina* L.** — Although noted in Fl. Bor.-Am. as ranging "to Bear Lake and the Rocky Mountains," this species has been collected in the Mackenzie basin east of the Rockies only in the more arctic areas toward the limit of trees. — Charlot Pt., L. Athabaska, no. 6383; Ft. Reliance, Great Slave L., no. 141.

***Poa pratensis* L.** — Common in damp meadows, prairies, and open woods throughout the forested region, with records at least as far northward as Great Bear Lake (*Richardson*, N; *J. M. Bell*, O). — Clearwater R., Sask., *J. M. Macoun*, no. 101824(O); Calumet, Athabaska R., no. 151. Lake Athabaska: Sand Pt., no. 4572; near mouth of Charlot R., nos. 6322, 6339; 5 mi. E. of Poplar Pt., no. 6679; point about 4 mi. E. of Wolverine Pt., no. 6808. Granite hill on E. shore of L. Mamawi, no. 1715; upper Slave R. lowlands, nos. 146, 1717, 1721, 1726; Ft. Smith, nos. 149, 152. Great Slave L.: Fairchild Pt., nos. 148, 150, 153; Ft. Reliance, no. 147.

***Poa lanata* Scribn. & Merrill.** — An Alaskan species known in the Mackenzie basin from a single collection south of Lake Athabaska, where it was found infrequently on partially fixed sand dunes. — Shifting sand dunes just E. of Ennuyeuse Cr., no. 6916.

POA COMPRESSA L. — Known in the Mackenzie basin only from the following collection. It is probably introduced. — Fort Smith, no. 142.

***Poa palustris* L.** — *P. triflora* of auth. — See Rhod. 18: 235 (1916). — Common in sloughs and on damp shores northward to the Wood Buffalo Park, but apparently extending only a short distance eastward into the pre-Cambrian. — McMurray, no. 7095; Calumet, Athabaska R., no. 151; lower delta of Athabaska R., nos. 143, 144; Shelter Pt., L. Athabaska, no. 145; E. shore of L. Mamawi, nos. 1707, 1710; Ft. Smith, nos. 151, 152.

***Poa glauca* L.** — Common on dry sandy shores and ridges, and in dry crevices on rocky hills throughout the forested region. Although no specimens are available from beyond the timber line it is probably to be found there also since it is a wide-ranging arctic species. — Clearwater R., Sask., *J. M. Macoun*, no. 29217(O); Calumet, Athabaska R., no. 154. Lake Athabaska: Chipewyan, nos. 6045, 7021; Shelter Pt., nos. 4460, 4461; Sand Pt., nos. 4494, 4502, 4602; Charlot Pt., nos. 6091, 6092, 6098, 6099, 6137, 6253, 6256, 6277, 6392, 6393, 6394, 6408; N.

shore of Ellis Bay, nos. 6112, 6125; shore of main lake just W. of Ellis Bay, no. 6270; rocky point at N. W. entrance to Black Bay, no. 6416; hill south of Wabba L., no. 6469; base of Cornwall Bay, nos. 6507, 6543; 5 mi. E. of Poplar Pt., no. 6644. East shore of L. Mamawi, nos. 1745, 1746, 1747; granite hills in upper Slave R. lowlands, no. 1743; Ft. Smith, no. 160; Cassette Portage, Slave R., *Kennicott* (N); island at east end of Black L., lat. 60° , *Harper*, no. 90049(O). Great Slave L.: Resolution, *Onion, Kennicott & Hardisty* (N); island at mouth of Rocher R., *Harper*, no. 90048(O); Taltheilei Narrows, nos. 155, 158; Fairchild Pt., nos. 156, 157, 161; Maufelly Pt., no. 159; Ft. Reliance, nos. 162, 163, 164.

Poa arida Vasey. — Found thus far only in the drier parts of semi-open prairies west of the Slave River, in the Wood Buffalo Park.

Poa glaucifolia Scribn. & Williams. — This appears to be a prairie species which has been found in our region only on a patch of clayey soil on a granite hill in the Athabaska-Peace delta. — East shore of L. Mamawi, no. 1748.

Poa Buckleyana Nash. — Found growing abundantly on a hillside of conglomerate rock on the north shore of Lake Athabaska, but not known elsewhere in the Mackenzie basin. — Charlot Pt., nos. 6255, 6289, 6410.

Distichlis stricta (Torr.) Rydb. — See Rhod. 27: 67 (1925). — Known in this region only on the Salt Plains west of the upper Slave River.

Phragmites communis Trin. var. ***Berlandieri*** (Fournier) Fern. — See Rhod. 34: 211 (1932). — Collected thus far only about the western end of Lake Athabaska, but probably common on river and lake shores in the southern part of the basin. — Lower delta of the Athabaska R., no. 1706; mouth of Athabaska R., *Harper*, no. 90061(O); shore of small lake near Sand Pt., L. Athabaska, no. 4604.

Schizachne purpurascens (Torr.) Swallen. — *Avena striata* Michx. — *Bromelica striata* (Michx.) Farwell. — *Melica purpurascens* (Torr.) Hitch. — See Jour. Wash. Acad. Sci. 18: 203 (1928). — Common in prairies and open woods northward to Lake Athabaska and the Wood Buffalo Park. — Clearwater R., Sask., *J. M. Macoun*, no. 30087(O); Calumet, Athabaska R., no. 192. Athabaska L.: west shore of Ellis Bay, no. 6168; Charlot Pt., no. 6407; Cornwall Bay, no. 6438.

Agropyron Smithii Rydb. var. ***molle*** (Scribn. & Sm.) Jones. — Collected thus far only on the drier part of a prairie at Peace Point in the Wood Buffalo Park.

Agropyron trachycaulum (Link) Malte var. ***typicum*** Fern. — *A.*

tenerum Vasey. — See Rhod. 35: 161–82 (1923) and 36: 417 (1934), also Ann. Rept. Nat. Mus. Can. for 1930, pp. 27–48 (1932) for treatments of this and the following. — Common in open woods, prairies, the drier parts of meadow sloughs, and on sandy lake beaches in the central and southern parts of the Mackenzie basin. It is known on the Mackenzie as far northwest as Ft. Norman (*Richardson*, G), but has not been recorded beyond the limit of trees. — Below Pelican Rapids, Athabaska R., *Harper*, no. 90057(O). Lake Athabaska: Cornwall Bay, no. 6443; hills south of Wabba L., no. 6473; cabin clearing about 3 mi. W. of Ennuyeuse Cr., no. 6956. East shore of L. Mamawi, nos. 1818, 1819; upper Slave R. lowlands, nos. 1810, 1811; Slave R., *Richardson* (G) (*Triticum caninum* of Fl. Bor.-Am., in part); Resolution, *Kennicott* (N).

Agropyron trachycaulum (Link) Malte var. *unilaterale* (Cassidy) Malte. — *A. Richardsonii* Schrad. — Common in upland prairies and the drier parts of meadow sloughs, with a range similar to the last. In the pre-Cambrian country it grows on sandy beaches and in small deposits of soil on the granite hills. — Lake Athabaska: Chipewyan, no. 4694; Shelter Pt., no. 179; Cornwall Bay, no. 6553. Upper Slave R. lowlands, nos. 1797, 1798.

Agropyron latiglume (Scribn. & Sm.) Rydb. — *A. caninum* (L.) R. & S. var. *latiglume* (Scribn. & Sm.) Pease & Moore. — *A. violaceum* (Hornem.) Lange var. *latiglume* Scribn. & Sm. — *A. biflorum* (Brign.) R. & S. var. *latiglume* (Scribn. & Sm.) Piper. — See Rhod. 35: 169 (1933), and Ann. Rept. Nat. Mus. Can. for 1930, pp. 27–48 (1932). — An arctic species probably extending south of the timber line locally in many places, but very little collected. Known also at Great Bear L. (*Richardson*, G; *J. M. Bell*, O). — Fort Reliance, Great Slave L., no. 180.

Arctophila fulva (Trin.) Rupr. — *Colpodium fulvum* (Trin.) Griseb. — See Rept. Can. Arct. Exped. 5: 6B (1922). — An arctic species known thus far in the Mackenzie basin from a single collection on the south shore of Great Slave Lake. — Black Bay, E. of mouth of Rocher R., Great Slave L., *Harper*, no. 90051(O).

Elymus canadensis L. — *E. robustus* Scribn. & Sm. var. *vestitus* Wieg. — See Rhod. 35: 187–98 (1933). — Occasional in the central part of the Mackenzie basin northward to Great Slave Lake, but not known in the pre-Cambrian country. — McMurray, no. 7072; Great Slave L., *Richardson* (G).

Elymus Macounii Vasey. — Known in this region only in the Salt River country, west of the upper Slave River.

Elymus innovatus Beal. — A common grass of dry woods, prairies and shores, extending northward to Great Bear Lake (*Richardson*, G) but apparently only occasional in the pre-Cambrian regions. — Methye Portage, Sask., *J. M. Macoun*, nos. 81134, 29780(O); Calumet, Athabaska R., no. 184; upper Slave R. lowland, nos. 1651, 1658. Ft. Smith, nos. 183, 185; Maufelly Pt., Great Slave L., no. 182.

Elymus arenarius L. var. **villosus** E. Mey. — See *Rhod.* 17: 98-103 (1915). — Common or abundant on sand beaches and dunes about the larger lakes. — Lake Athabaska: Shelter Pt., nos. 181, 4421; Sand Pt., no. 4575; shore of main lake just W. of Ellis Bay, no. 6269; 2 mi. E. of Wolverine Pt., no. 6717; shifting dunes just E. of Ennuyouse Cr., no. 6915; E. end of L. Athabaska, *J. W. Tyrrell*, no. 29826(O). Great Slave L.: S. W. and N. shores, *Howe*, no. 91989(O); N. W. shore, *Bedford* (O).

Hordeum jubatum L. — Common on dry sandy shores, prairies, and in cabin clearings throughout the central and southern parts of the Mackenzie basin, but only occasional eastward in the pre-Cambrian areas. Noted on the Mackenzie by *Richardson*. — Lake Athabaska: Shelter Pt., no. 193; 3 mi. W. of Ennuyouse Cr., no. 6957. East shore of L. Mamawi, no. 1630; Resolution, *Harper*, no. 90056(O).

HORDEUM VULGARE L. — Barley is cultivated successfully as far northward as Aklavik, in the Mackenzie delta, and is occasionally seen about settlements and cabin clearings as an escape. — Upper Slave R. lowland (Government Hay Camp), no. 1635.

Koeleria cristata (L.) Pers. — Common on dry prairies and bluffs west of the upper Slave River.

Trisetum spicatum (L.) Richter var. **molle** (Michx.) Beal. — *T. subspicatum* (L.) Beauv. var. *molle* Gray. — See *Rhod.* 18: 195 (1916), and 30: 239 (1928). — Common on sandy beaches or in damp shore rock crevices throughout the pre-Cambrian country and northward to Great Bear Lake (*Richardson*, G, N; *J. M. Bell*, O). Occasional in the Paleozoic regions. — Lake Athabaska: Shelter Pt., nos. 174, 4457; Sand Pt., nos. 4503, 4504; Charlot Pt., nos. 6131, 6249, 6389; W. shore of Ellis Bay, no. 6374; shore of main lake just W. of Ellis Bay, no. 6272; rocky point at N. W. entrance to Black Bay, nos. 6417, 6421; Cornwall Bay, no. 6545; 5 mi. E. of Poplar Pt., no. 6653. Great Slave L.: Keith Isl., no. 175; Fairchild Pt., no. 176.

Sphenopholis pallens (Spreng.) Scribn. — Occasional on sandy shores of lakes and streams in the Wood Buffalo Park.

Avena Hookeri Scribn. — Found thus far only on the drier parts of a prairie at Peace Point, in the Wood Buffalo Park.

AVENA FATUA L. var. *GLABRATA* Peterm. — Found in this region only as an introduced weed in cabin clearings. — Upper Slave R. lowland (Government Hay Camp), no. 1638.

AVENA SATIVA L. — Successfully cultivated far northward in the Mackenzie valley, and known to ripen in the delta of that river. — Upper Slave R. lowland (Government Hay Camp), no. 1637.

Deschampsia cespitosa (L.) Beauv. var. *glauca* (Hartm.) Lindm. — See Rhod. 28: 154 (1926). — Common about the margins of wet sloughs and on damp sandy or rocky shores in the forested central parts of the Mackenzie basin and southward. Noted by Richardson in Fl. Bor.-Am. on Great Bear Lake. — Calumet, Athabaska R., no. 209. Lake Athabaska: Shelter Pt., nos. 207, 208, 210, 211; Sand Pt., nos. 4499, 4647; mouth of Charlot R., no. 6337, and *Harper*, no. 90053(O); W. shore of Ellis Bay, no. 6368; Charlot Pt., no. 6382; Cornwall Bay, no. 6552. Peace R. delta, no. 216; upper Slave R. lowland, nos. 1660, 1662, 1664. Great Slave L.: Keith Isl., no. 217; Fairchild Pt., nos. 212, 213, 215; Ft. Reliance, no. 214.

Deschampsia mackenzieana, sp. nov.

PLATE 190¹

Gramen perenne caespitosum, 3–8 dm. altum, paniculis laxis patulis 12–20 cm. longis, 8–14 cm. latis, ramis gracilibus infra medium divisis et basi excepta scabris; caules graciles, glabri; folia angusta, involuta, dimidio breviora quam planta, laminis et vaginis glabris; ligulae lanceolatae, 3–5 mm. longae. Spiculae 6–7 mm. longae; glumae aequilongae, acute acuminatae, apicem floris superioris circa attingentes, sed ab arista superatae; spiculae 1–2-florae, lemmatibus circa 4.5–5.5 mm. longis laevigatis scariosis, apice acuto erosis, 4-nerviis (nervo medio aristam formante), paleis scariosis 2-nerviis apice erosis 3.5–4.5 mm. longis, nervis scabris; aristae ad medium lemmatum vel $\frac{2}{3}$ basin versus insertae, et lemmatibus circa 2 mm. longiorae; rhachilla in stipitem pilosum quam palea triente breviorum producta pilis apicem paleae subattingentibus; caryopsis circa 2 mm. longa. — Sandy beach on the south shore of Lake Athabaska near Wolverine Point, July 30, 1935, no. 6707 (Type, G). Another number, 6904, collected August 20, 1935 on the large shifting dunes southwest of William Point, is more mature and smaller in stature, but otherwise matches the type very well. — This species is most nearly related to far-northwestern American forms commonly labeled *D. bottnica* (Wahl.) Trin., and to a species described

¹PLATE 190. *Deschampsia mackenzieana* Raup. Part of type collection from sandy beach ridges just east of Wolverine Pt., Lake Athabaska, no. 6707; details of spikelets $\times 5$.

from the Bering Sea region by Hultén,¹ *D. beringensis*. From both of these it differs in its larger spikelets (up to 7 mm.), and in its spreading panicles. *D. bottnica* has glumes up to 6 mm. long, but commonly shorter, and *D. beringensis* has them 4–5 mm. long. In both the panicles are characteristically contracted, with upright branches. The awn in *D. bottnica* of the Baltic region is often longer than in our plant, exceeding the lemma by more than 3 mm. From *D. beringensis*, *D. mackenzieana* also differs in having smooth lemmas with awn commonly attached near the middle instead of scabrous lemmas with awns from near the base, in having 2-flowered spikelets instead of having them "often 3-flowered," and in having strongly involute leaves with short ligules (3–5 mm.) instead of flat leaves with ligules 8–13 mm. long. The Athabaska Lake plant is one of the commonest species on the sandy beaches and dunes which line the south shore, and is a prominent sand-binding agent.

Danthonia intermedia Vasey. — Occasional in dry upland prairies of the Paleozoic or younger country, and in small deposits of dry soils about the western end of Lake Athabaska. — Chipewyan, no. 4697.

Danthonia thermalis Scribn. — Apparently rare or occasional on rocky hills about the north shore of Lake Athabaska, but not found elsewhere in the region. — Northwest of Sand Pt., no. 4610; Cornwall Bay, no. 6449.

Calamagrostis purpurascens R. Br. — See Rhod. 35: 213 (1933). — Frequent in dry rock crevices and on sandy ridges and beaches, chiefly in the pre-Cambrian country but wide-ranging in the Arctic. Not observed on the south side of Lake Athabaska. — Lake Athabaska: Shelter Pt., nos. 253, 4462; Charlot Pt., nos. 6096, 6285, 6287, 6304; Cornwall Bay, no. 6510. Near Selwyn L., lat. 60°20', long. 104°30', J. W. Tyrrell, no. 28921(O). Ft. Smith, no. 260. Great Slave L.: Taltheilei Narrows, no. 256; Maufelly Pt., no. 262; Fairchild Pt., nos. 257, 258, 259, 261; Ft. Reliance, nos. 254, 255.

Calamagrostis montanensis Scribn. — Known in this region from a single collection on the dry prairie at Peace Point, in the Wood Buffalo Park.

Calamagrostis canadensis (Michx.) Nutt. — See Rhod. 24: 142 (1922), and 32: 42 (1930) for treatments of this and its related forms. — This species, with its variety *robusta* is abundant in the moister portions of upland semi-open prairies and at the willow margins of the extensive sloughs in the great river lowlands northward at least

¹Hultén, Eric. *Flora of Kamtchatka and the Adjacent Islands*. 1: 107-8 (1927) (Svensk. Vetensk. Akad. Handl. ser. 3, 5, no. 1).

to Great Slave Lake. In the deltas of the Peace and Athabaska Rivers it forms wide expanses in nearly pure stands, and has been extensively used as a source of wild hay. Eastward in the pre-Cambrian country it occupies slough margins and damp sandy lake shores. — Calumet, Athabaska R., no. 234; Egg L., Athabaska R. delta, *Harper*, no. 47 (G). Lake Athabaska: Shelter Pt., nos. 233, 235, 236, 237; 5 mi. E. of Poplar Pt., nos. 6645, 6678; along Archibald R. near its mouth, no. 6738; 2 mi. W. of Ennuyouse Cr., no. 6999. East shore of L. Mamawi, nos. 1755, 1756, 1757; upper Slave R. lowland, nos. 1751, 1753; lower Slave R., near Pt. Brulé, nos. 231, 232. Great Slave L.: mouth of Rocher R., *Harper*, no. 90055(O); Yellowknife Bay, no. 230.

Calamagrostis canadensis (Michx.) Nutt. var. ***robusta*** Vasey. — Apparently the commoner form of the species over much of its area. So far as present knowledge indicates, it is more widely distributed in the Mackenzie basin, having been found on the lower Mackenzie River (*Taylor*, O). — Lower Athabaska R.: *Kennicott* (N); Calumet, no. 240. Lake Athabaska: Shelter Pt., nos. 241, 242, 243, 244; Sand Pt., nos. 4574, 4609; mouth of Charlot R., no. 6358, and *Harper*, no. 90058(O); near Wabba L., N. of Cornwall Bay, no. 6481. Tazin R., N. W. T., *Harper*, no. 90059(O). Great Slave L.: Black Bay, E. of Rocher R., *Harper*, nos. 90052, 90054(O); Keith Isl., no. 239; Fairchild Pt., nos. 238, 245, 248, 250, 251; Ft. Reliance, nos. 246, 247, 249; Yellowknife Bay, no. 252; N. W. shore, *Bedford* (O).

Calamagrostis canadensis (Michx.) Nutt. var. ***scabra*** (Presl) Hitchc. — See *Am. Jour. Bot.* 21: 135 (1934). — An arctic form of the species which apparently reaches southward into the margins of the timbered region. Also collected on the west branch of the Thelon River (*J. W. Tyrrell*, O), and at Great Bear Lake (*Richardson*, N). — Black L., E. of L. Athabaska, *J. W. Tyrrell*, no. 17390(O); Black R., *J. W. Tyrrell*, no. 17421(O) (both *C. Langsdorfi* in *Tyrrell's* list).

Calamagrostis inexpansa Gray var. ***brevior*** (Vasey) Stebbins. — See *Rhod.* 32: 50 (1930). — Common or occasional in semi-open prairies and on the slough margins of lakes and ponds northward to Great Bear Lake (*Richardson*, N). — Lake Athabaska: Cornwall Bay, no. 6554; 5 mi. E. of Poplar Pt., no. 6649; pond margin about 5 mi. S. E. of Wolverine Pt., no. 6810. Upper Slave R. lowlands, nos. 1773, 1777, 1778. Yellowknife Bay, Great Slave L., no. 229.

Calamagrostis neglecta (Ehrh.) Gaertn. — See *Rhod.* 32: 53–6 (1930). — Abundant on sandy beaches and dunes on the south side of Lake Athabaska, but apparently rare or occasional elsewhere in the Mackenzie basin. — Lake Athabaska: 2 mi. E. of Wolverine Pt., no. 6722; shifting dunes just E. of Ennuyouse Cr., nos. 6909, 6925.

Agrostis borealis Hartm. var. *typica* Fern. — See Rhod. 35: 203-7 (1933). — An arctic species known in the Mackenzie basin only toward the northern margin of the timber. It grows on damp rocky or sandy shores. — Rocky point at N. W. entrance to Black Bay, L. Athabaska, no. 6412; Fairchild Pt., Great Slave L., no. 225.

Agrostis scabra Willd. — *A. hyemalis* of auth., in part. — See Rhod. 35: 207-12 (1933). — Common in prairie openings, the drier parts of meadow sloughs, and in damp crevices or sandy shores throughout the forested area northward at least to Great Bear Lake (*Richardson*, G). — Lower Athabaska R., *Kennicott* (O). Lake Athabaska: Shelter Pt., 218, 219, 220, 221, 222, 223; near Sand Pt., nos. 4501, 4646; Cornwall Bay, nos. 6442, 6557; 5 mi. E. of Poplar Pt., no. 6699; sand hills, 4 mi. S. E. of Wolverine Pt., no. 6790; pond margin about 5 mi. S. E. of Wolverine Pt., no. 6831. Above Great Falls, Tazin R., *Harper*, no. 90060(O). East shore of L. Mamawi, nos. 1624, 1625; upper Slave R. lowland, nos. 1626, 1627. Fairchild Pt., Great Slave L., no. 224.

Cinna latifolia (Trev.) Griseb. — This species has been very little collected in the Mackenzie basin, although it is probably common in the rich woods of the southern portions. — McMurray, no. 7105; Reed's Portage, upper Athabaska delta, no. 1827; Chipewyan, no. 4678.

Arctagrostis arundinacea Trin. — Apparently rare in the Mackenzie basin, in spite of the rather wide range assigned to it by *Richardson* ("Cumberland House to Bear Lake"). East of the mountains it has been found only at the eastern edge of the Caribou Mountain Plateau (See Nat. Mus. Can. Bull. 74, p. 109).

Alopecurus aequalis Sobol. — *A. aristulatus* Michx. — *A. geniculatus* var. *aristulatus* (Michx.) Torr. — See Rhod. 27: 196 (1925). — Occasional on sandy or muddy shores and in semi-dry sloughs northward to Great Bear Lake (*Richardson*, G). Rather common in clearings. It has not been found in the pre-Cambrian country about Lake Athabaska. — Methye Portage, Sask., *J. M. Macoun*, no. 18622(O); McMurray, no. 7100; Reed's Portage, upper Athabaska delta, no. 1607; lower delta of Athabaska R., no. 187; E. shore of L. Mamawi, no. 1605; upper Slave R. lowland, no. 1606; Ft. Smith, no. 188. Great Slave L.: Maufelly Pt., no. 186; Fairchild Pt., nos. 189, 190, 191.

Phleum alpinum L. — Specimens somewhat doubtfully referred to this species have been collected in the Wood Buffalo Park, situated in such a way as to suggest that they are but forms of the introduced *P. pratense*. — Reed's Portage, upper Athabaska R. delta, no. 1790; upper Slave R. lowland (Government Hay Camp), no. 1791.

PHLEUM PRATENSE L. — Introduced in settlements and cabin clearings in the Wood Buffalo Park.

Muhlenbergia Richardsonis (Trin.) Rydb. — See Bull. Torr. Bot. Club, 32: 600 (1905). — Known in the Mackenzie basin only from collections in the Salt Plains west of the upper Slave River.

Oryzopsis pungens (Torr.) Hitchc. — Occasional in dry woods, apparently throughout the region north to the Wood Buffalo Park. — Clearwater R., Sask., *J. M. Macoun*, no. 29426(O); Calumet, Athabaska R., no. 226. Lake Athabaska: Sand Pt., no. 4624; Charlot Pt., nos. 6106, 6406, 6409; N. shore of Ellis Bay, no. 6116; Cornwall Bay, no. 6509; sand hills about 4 mi. S. E. of Wolverine Pt., no. 6791. Upper delta of Peace R. (Quatre Fourches R.), no. 227.

Oryzopsis canadensis (Poir.) Torr. — See Contr. U. S. Nat. Herb. 24: 227 and 262 (1925). — Known in this region only in the Salt River country west of the upper Slave River. This species was omitted from the Wood Buffalo Park Catalogue. — Salt R. region, *Camsell*, no. 92000(O).

Oryzopsis asperifolia Michx. — Occasional in dry upland woods northward at least to the Wood Buffalo Park, but not known eastward in the pre-Cambrian region. — Calumet, Athabaska R., no. 228; along Firebag R., near its mouth, no. 6035.

Stipa comata Trin. & Rupr. — A species of the Great Plains which enters our region only on dry prairies in the Wood Buffalo Park, where it is rather common at Peace Point.

Stipa comata Trin. & Rupr. var. *intermedia* Scribn. — Known in our region from a single collection on a granite hill in the Peace-Athabaska delta. — East shore of L. Mamawi, no. 1687.

Stipa Richardsonii Link. — Known in this region only on the dry prairie at Peace Point, in the Wood Buffalo Park.

Beckmannia Syzigachne (Steud.) Fern. — *B. erucaeformis* Amer. auth., not Host. — *B. baicalensis* (W. Kuznetsov) Hultén. — See Rhod. 30: 27 (1928). — Common on wet pond margins and in meadow sloughs northward to the Mackenzie (*Miss E. Taylor*, N, O). — McMurray, no. 7099; Calumet, Athabaska R., no. 195; N. shore of Ellis Bay, L. Athabaska, no. 6170; E. shore of L. Mamawi, nos. 1639, 1640; upper Slave R. lowland, nos. 1643, 1644. Great Slave L.: Fairchild Pt., nos. 196, 197; Ft. Rae, *Bedford* (O).

Spartina gracilis Trin. — Known in this region only on the Salt Plain prairies west of the Slave R., where it is common. A Richardson specimen in the Gray Herbarium, originally labeled *S. polystachya*, bears the notation "Cumberland House to Bear Lake." This notation

may include, however, the range of *S. pectinata* which may also have been included in *S. polystachya*.

Spartina pectinata Link. — *S. Michauxiana* Hitchc. — See Rhod. 35: 258–60 (1933). — Apparently rare or occasional, and known thus far from two widely separated collections. Richardson's record for *S. polystachya*, "Cumberland House to Bear Lake," probably refers in part to this species. — McMurray, no. 7058; Resolution, *Onion, Kennicott & Hardisty* (N).

Hierochloë odorata (L.) Wahl. — *Torresia odorata* (L.) Hitchc. — Common in prairie openings, damp beaches, meadows and rock crevices northward at least to Great Slave Lake. — Clearwater R., Sask., *J. M. Macoun*, no. 29488(O); Calumet, Athabaska R., no. 172. Lake Athabaska: Sand Pt., nos. 4566, 4660; N. shore of Ellis Bay, no. 6124; Charlot Pt., nos. 6220, 6241; mouth of Charlot R., no. 6336. Upper delta of Peace R., no. 173; Mountain Portage, Slave R., *Kennicott* (N); Resolution, *Kennicott* (N).

Phalaris arundinacea L. — Occasional in damp meadows in the upland districts of the Wood Buffalo Park, but common in the lowlands about the western end of Lake Athabaska. — Upper Athabaska delta (Mamawi Cr.), no. 1702; lower delta of Athabaska R., no. 198; E. shore of L. Mamawi, no. 1703.

Panicum subvillosum Ashe. — Known in the Mackenzie basin from a single collection south of Lake Athabaska. — Burnt pine woods on sandy ridges along lower Archibald R., no. 6746.

CYPERACEAE

Eriophorum Scheuchzeri Hoppe. — An arctic species known in this region only about Great Slave Lake, but collected farther northward at Great Bear Lake, and on the Mackenzie (*J. M. Bell*, O; *Kennicott* ?, N). — Great Slave L.: Taltheilei Narrows, no. 364; Maufelly Pt., no. 363.

Eriophorum Chamissonis C. A. Mey. forma *albidum* (F. Nyl.) Fern. — See Rhod. 23: 131 (1921), and 27: 207 (1925). — Occasional in wet muskegs, chiefly in the pre-Cambrian region. — Lake Athabaska: Shelter Pt., nos. 356, 357; near shore of Royal L., S. of Turnor Pt., no. 6841. Great Slave L.: Resolution, *Kennicott* (N); Fairchild Pt., no. 358.

Eriophorum opacum (Björnstr.) Fern. — Common in muskegs northward to Great Slave Lake. — Clearwater R., Sask., *J. M. Macoun*, no. 32297(O); Calumet, Athabaska R., no. 367. Lake Athabaska: Shelter Pt., nos. 365, 366; mouth of Charlot R., no. 6315; N. of Cornwall Bay, no. 6530; 5 mi. E. of Poplar Pt., nos. 6696, 6703. Great Slave

L.: Taltheilei Narrows, no. 370; Maufelly Pt., no. 368; Fairchild Pt., no. 369.

Eriophorum vaginatum L. — See Rhod. 27: 203-10 (1925) for a treatment of this and the following three spp. — An arctic species evidently quite rare in the Mackenzie basin, and known thus far from a single locality. — Artillery L., *J. W. Tyrrell*, no. 23138(O), and *Seton & Preble*, no. 78570(O).

Eriophorum spissum Fern. — *E. callitrix* of most Amer. auth. — Common or occasional in the Wood Buffalo Park and southwestward, but not recorded thus far in the pre-Cambrian region. Also found on the lower Mackenzie (*Stringer*, O).

Eriophorum angustifolium Roth. — Common in muskegs in the pre-Cambrian region, and extending northward to Great Bear Lake (*J. M. Bell*, O), but rare or occasional in the Wood Buffalo Park. — Lake Athabaska: near Sand Pt., no. 4537; mouth of Charlot R., no. 6342; 5 mi. E. of Poplar Pt., no. 6659; about 4 mi. S. E. of Wolverine Pt., no. 6784; muskeg about 5 mi. S. E. of Wolverine Pt., no. 6809; William Pt., no. 6844; 2 mi. W. of Ennuyeuse Cr., no. 6996. Great Slave L.: mouth of Mountain R., no. 359; Fairchild Pt., nos. 360, 361, 362.

Eriophorum tenellum Nutt. — Known thus far in this region only from the south side of Lake Athabaska, where it inhabits muskeg shores. — Lake Athabaska: William Pt., no. 6864; muskeg about 3 mi. W. of Ennuyeuse Cr., no. 6971.

Eriophorum viridicarinatum (Engelm.) Fern. — Apparently rare; and found thus far only in the pre-Cambrian parts of this region, where it inhabits sandy lake beaches and muskegs. — Shelter Pt., L. Athabaska, no. 4441; Fairchild Pt., Great Slave L., no. 372.

Scirpus hudsonianus (Michx.) Fern. — *Eriophorum alpinum* L. — Occasional in muskegs, chiefly in the pre-Cambrian country. — Lake Athabaska: near Sand Pt., no. 4643; Camsell Portage, no. 6210; mouth of Charlot R., no. 6329; area of large dunes about 5 mi. S. of William Pt., no. 6880. Great Slave L.: Fairchild Pt., no. 385.

Scirpus cespitosus L. var. **callosus** Bigel. — See Rhod. 23: 22 (1921). — Locally common in muskegs in the pre-Cambrian areas, where it appears to be limited to districts where sedimentary rocks occur. Noted in Fl. Bor.-Am. (under *Eleocharis*) as occurring throughout Canada to the shores of the Arctic Sea, but the writer has seen no material from north of Great Slave Lake. — Lake Athabaska: near Sand Pt., no. 4625; in large dune area about 5 mi. S. of William Pt., no. 6896. Great Slave L.: Taltheilei Narrows, no. 389; Maufelly Pt., no. 392; Fairchild Pt., nos. 390, 391.

Scirpus validus Vahl. — Abundant on marshy lake shores northward in the Paleozoic and younger country throughout the Wood Buffalo Park, and at least occasional beyond Great Slave Lake (*Bedford*, O). Apparently absent from the pre-Cambrian region. — Lower delta of Athabaska R., nos. 386, 1980; E. shore of L. Mamawi, no. 1982.

Scirpus paludosus A. Nels. — Known in this region only on the Salt Plains west of the upper Slave River, in the Wood Buffalo Park.

Scirpus microcarpus Presl. — Occasional in marshes northward to Great Slave Lake, but apparently limited to the great river lowlands. — Calumet, Athabaska R., no. 388; L. Athabaska, *John Macoun*, no. 32389(O) (*S. sylvaticus* var. *digynus* of Macoun's Cat.); Resolution, *Kennicott* (N).

Scirpus atrocinctus Fern. — Unknown in the Mackenzie basin except on the shores of Lake Athabaska. It inhabits wet shores. — Lake Athabaska; Shelter Pt., no. 387; Sand Pt., no. 4576; mouth of Archibald R., no. 6753.

Scirpus rubrotinctus Fern. — Known in the Mackenzie basin from a single collection on the south shore of Lake Athabaska, where it was growing on sand in about 8 inches of water. — Mouth of Archibald R., no. 6752.

Eleocharis pauciflora Link. — See *Rhod.* 36: 377-86 (1934). — Apparently rare, and collected thus far only from two localities in the pre-Cambrian country. — Sandy pond margin about 5 mi. S. E. of Wolverine Pt., L. Athabaska, no. 6833; stony-sandy shore of Keith Isl., Great Slave Lake, no. 374.

Eleocharis palustris (L.) R. & S. — Noted in Fl. Bor.-Am. and Macoun's Cat. as occurring "Throughout Canada to Bear Lake," but the writer has seen no specimens from north of Lake Athabaska and the Wood Buffalo Park. Common to abundant on marshy shores. — Lower delta of Athabaska R., nos. 381, 1963. Lake Athabaska: Shelter Pt., no. 382; pond just N. of Cornwall Bay, no. 6627; 2 mi. W. of Ennuyeuse Cr., nos. 6991, 6994. East shore of L. Mamawi, no. 1964; delta of Peace R., no. 380; upper Slave R. lowland, nos. 384, 1968, 1969; Ft. Smith, no. 383.

Eleocharis calva Torr. — See *Rhod.* 31: 68 (1929). — Collected in the Mackenzie basin thus far only on the muddy shore of Slave River. — Upper Slave R. lowland (Government Hay Camp), no. 1973.

Eleocharis uniglumis (Link) Schultes. — See *Rhod.* 31: 71 (1929). — On slough margins and damp river banks northward to the Wood Buffalo Park, but apparently not common. It has not been collected in the pre-Cambrian country. — Calumet, Athabaska R., no.

376; island in Slave R. at 30th base line, not far below the mouth of the Peace, no. 375.

Eleocharis acicularis (L.) R. & S. — Common in muddy slough margins in the Wood Buffalo Park and southward, but apparently reaching eastward into the pre-Cambrian only a short distance. — Lower delta of Athabaska R., no. 377. Lake Athabaska: Shelter Pt., nos. 378, 379; Sand Pt., no. 4570; "Athabaska," *Richardson*, no. 32179(O). Upper Slave R. lowland, no. 1974.

Kobresia simpliciuscula (Wahl.) Mackenzie. — Known in the Mackenzie basin from a single collection on Great Slave Lake. — Muskeg pond margin, Fairchild Pt., no. 373.

Carex capitata L. — Apparently rare, and found in muskeg thickets both in the pre-Cambrian country and in the Wood Buffalo Park. It was collected on Methye River by J. M. Macoun (O) in 1888. — Taltheilei Narrows, Great Slave Lake, nos. 329, 330.

Carex Eleocharis Bailey. — *C. stenophylla* of auth., not Wahl. — See N. Am. Fl. 18: 33-4 (1931). — A northern plains species which has been found only in a small patch of clayey soil on a granite hill in the Athabaska-Peace delta. — Granite knoll on E. shore of L. Mamawi, no. 1958.

Carex Sartwellii Dewey. — Apparently rare in the Wood Buffalo Park and southward, and thus far known only from Paleozoic or younger rocks. It is found in wet meadows. — Clearwater R., Sask., *J. M. Macoun*, no. 31810(O).

Carex siccata Dewey. — Common in dry woods, prairies and sandy shores northward at least to Great Slave Lake. — Clearwater R., Sask., *J. M. Macoun*, nos. 20502, 30306(O); Calumet, Athabaska R., no. 298. Lake Athabaska: Shelter Pt., no. 300; Sand Pt., no. 4622; sandy shore of main lake just W. of Ellis Bay, no. 6267; mouth of Charlot R., no. 6316; Cornwall Bay, no. 6511; along Archibald R. near its mouth, no. 6733. Upper Slave R. lowland, no. 1936; Ft. Smith, no. 297. Great Slave L.: Maufelly Pt., no. 299.

Carex chordorrhiza Ehrh. — Known in the Mackenzie basin only from two localities about Lake Athabaska. It grows in wet muskegs or wet mossy rock crevices. — Lake Athabaska: Cornwall Bay, no. 6551; about 3 mi. W. of Ennuyeuse Cr., no. 6970.

Carex diandra Schrank. — Common on the marshy shores of lakes and ponds northward to Great Slave Lake. Collected on Methye River by J. M. Macoun in 1888. — Lake Athabaska: muskeg pond margins just N. of Cornwall Bay, nos. 6497, 6630. Great Slave L.: Fairchild Pt., no. 294; Yellowknife Bay, no. 293.

Carex disperma Dewey. — *C. tenella* Schkuhr. — Common in muskeg thickets and sloughs northward at least to Lake Athabaska and the Wood Buffalo Park. — Lake Athabaska: Shelter Pt., nos. 306, 307, 4454; near Sand Pt., no. 4512; near mouth of Charlot R., nos. 6345, 6347.

Carex tenuiflora Wahl. — Occasional in damp rock crevices and muskegs, chiefly in the pre-Cambrian country but known also west of the Slave River. — Lake Athabaska: mouth of Charlot R., no. 6321 rocky point at N. W. entrance to Black Bay, no. 6420; 5 mi. E. of Poplar Pt., no. 6682. Great Slave L.: Taltheilei Narrows, no. 336; Fairchild Pt., no. 335.

Carex loliacea L. — A species of far-northwestern affinity known in the Mackenzie basin from three widely separated localities: Lesser Slave Lake, the eastern edge of the Caribou Mountain plateau, and the north shore of Lake Athabaska. — Muskeg N. of Cornwall Bay, L. Athabaska, no. 6483.

Carex brunnescens Poir. var. **sphaerostachya** (Tuckerm.) Kükenth. — See Rhod. 28: 163 (1926). — Occasional at muskeg slough margins or in damp crevices northward at least to Lake Athabaska and the Wood Buffalo Park. — Clearwater R., Sask., *J. M. Macoun*, no. 30476(O). Lake Athabaska: near Sand Pt., nos. 5412-a, 4605; 5 mi. E. of Poplar Pt., nos. 6650, 6672; along Archibald R., S. of Wolverine Pt., no. 6726; slough along William R. near its mouth, no. 6879.

Carex canescens L. var. **subloliacea** Laestad. — Common at muskeg pond margins throughout the region northward at least to Great Slave Lake. Noted by both Richardson and John Macoun on Methye Portage. — Lake Athabaska: Shelter Pt., nos. 320, 321, 322; near Sand Pt., nos. 4496, 4607; near mouth of Charlot R., no. 6346; just N. of Cornwall Bay, nos. 6494, 6620; 5 mi. E. of Poplar Pt., nos. 6661, 6662, 6694, 6697; along Archibald R., S. of Wolverine Pt., no. 6725; along William R. near its mouth, no. 6878. Great Slave L.: Fairchild Pt., nos. 323, 324; 12 mi. E. of Moraine Pt., N. W. shore, *Bedford* (O).

Carex arcta Boott. — Occasional in wet upland thickets in the Wood Buffalo Park and southwestward.

Carex gynocrates Wormsk. — Common in mossy muskeg timber and thickets northward to Great Slave Lake, and known also in the Arctic. — Clearwater R., *J. M. Macoun*, no. 30560(O). Lake Athabaska: Shelter Pt., no. 331; mouth of Charlot R., nos. 6325, 6327. Great Slave L.: Maufelly Pt., no. 333; Fairchild Pt., nos. 332, 334.

Carex Deweyana Schw. — Common or occasional in woods and thickets at the southern borders of the region. — Methye Portage, *J. M. Macoun*, no. 30463(O); McMurray, no. 7046.

Carex praticola Rydb. — *C. pratensis* Drejer. — Common in prairie openings and open woods northward in the Paleozoic and younger country at least to the Wood Buffalo Park. — Clearwater R., Sask., J. M. Macoun, nos. 31668(O); 13403(G, O); granite hill on E. shore of L. Mamawi, no. 1905.

Carex Crawfordii Fern. — Collected in this region only in one locality on the northwest shore of Lake Athabaska, where it is rather common on damp stony beaches. A Richardson specimen in the Gray Herbarium is marked "Carlton House and Bear Lake," but we have no other indication that the species occurs so far northward. It is also known in the southwestern part of the Mackenzie basin. — Shelter Pt., L. Athabaska, nos. 290, 291, 292, 4439.

Carex Bebbii Olney. — Occasional at damp slough margins northward to the Athabaska River delta and the lower Peace River, and common in the southwestern part of the Mackenzie basin. Collected on Methye River by J. M. Macoun. — Reed's Portage, upper Athabaska delta, no. 1959.

Carex tenera Dewey. — Occasional on damp upland slough margins in the Wood Buffalo Park, but otherwise unknown in the Mackenzie basin.

Carex aenea Fern. — Occasional in rock crevices and on dry sandy beaches and plains on the north shore of Lake Athabaska, but not known elsewhere in the Mackenzie basin. — Chipewyan, no. 6074; near Sand Pt., nos. 4506, 4623; N. shore of Ellis Bay, no. 6110; Charlot Pt., no. 6254.

Carex sychnocephala Carey. — Known in the Mackenzie basin from only two localities, one in the Wood Buffalo Park, and the other at the western end of Lake Athabaska. — Damp roadway just back of Chipewyan, no. 7017.

Carex leptalea Wahl. — Occasional in muskegs in the pre-Cambrian parts of this region, and known northward along the Mackenzie (*Richardson*, N). — Shore of L. Athabaska near Sand Pt., no. 4489; Fairchild Pt., Great Slave L., no. 304.

Carex obtusata Liljebl. — A species of dry prairies found in this region only in the Wood Buffalo Park, and on dry turfy slopes at the western end of Lake Athabaska. — Chipewyan, nos. 4681, 6070.

Carex supina Wahl. — Apparently rare, and found thus far only in the pre-Cambrian region where it grows on exposed rocky or sandy slopes. Also known at Great Bear Lake (*Richardson*, G, N). — Lake Athabaska: Charlot Pt., nos. 6101, 6288; high hill S. of Wabba L., no. 6470. Great Slave L.: Ft. Reliance, no. 283.

Carex deflexa Hornem. — Occasional in dry rock crevices and gravelly or sandy shores about Lake Athabaska, but otherwise unknown in the Mackenzie basin east of the mountains except at Methye Portage. — Methye Portage, *Richardson* (O) (*C. novae-angliae* of Rich. Arctic Searching Exped.). Lake Athabaska: north shore of Charlot Isl., nos. 6166, 6167; Camsell Portage, no. 6205; Cornwall Bay, no. 6456; high hill S. of Wabba L., no. 6471; 5 mi. E. of Poplar Pt., no. 6651; about 4 mi. S. E. of Wolverine Pt., no. 6793?

Carex Rossii Boott. — Apparently rare, and known thus far only in the Paleozoic and younger country northward to the Wood Buffalo Park, where it inhabits dry soils. — Clearwater R., Sask., *J. M. Macoun*, no. 32007(O); Ft. Smith, no. 326.

Carex umbellata Schkuhr var. **tonsa** Fern. — *C. tinsa* (Fern.) Bicknell. — Noted by Richardson in 1845 at Methye Portage and Ft. Simpson, but the writer has seen only the following material. — Lake Athabaska: Chipewyan, *Richardson* (G) (*C. umbellata* of Fl. Bor.-Am. and Macoun's Cat.); open woods of small jack pine S. of Wolverine Pt., no. 6724.

Carex scirpoidea Wahl. — An arctic and alpine species known in this region only from the pre-Cambrian country, where it grows in muskegs or rocky crevices and slopes, and seems to be confined to dolomitic rocks. — Lake Athabaska: Cornwall Bay, nos. 6447, 6448; hills N. W. of Cornwall Bay, no. 6522. Great Slave L.: Taltheilei Narrows, no. 309; Fairchild Pt., nos. 308, 310, 311; N. W. shore, *Bedford* (O).

Carex concinna R. Br. — Occasional or common in muskeg thickets or damp crevices throughout the wooded region northward to Great Bear Lake (*Richardson*, G). — Lake Athabaska: Charlot Pt., nos. 6227, 6301, 6385; west shore of Ellis Bay, no. 6372; rocky hills N. W. of Cornwall Bay, no. 6537. Great Slave L.: Taltheilei Narrows, no. 265; Maufelly Pt., no. 263; Fairchild Pt., no. 264.

Carex Richardsonii R. Br. — Common or occasional on dry bluffs and in dry open woods northward to the Wood Buffalo Park, but scarcely extending into the pre-Cambrian region. — Along Firebag R. near its entrance to the Athabaska, no. 6039; Chipewyan, no. 6076; Ft. Smith, nos. 303, 1885.

Carex glacialis Mackenzie. — *C. pedata* Wahl. — An arctic species, apparently rare in the Mackenzie basin and known only from the following localities. It grows on high rock ledges, and seems confined to dolomitic rocks. — Hills N. E. of Cornwall Bay, L. Athabaska, no. 6521; Fairchild Pt., Great Slave L., no. 282.

Carex eburnea Boott. — Although originally described from ma-

terial collected by Richardson at Fort Norman on the Mackenzie, this species has been collected in only one other place in the Mackenzie basin east of the mountains. — Dolomitic hills N. E. of Cornwall Bay, no. 6520.

Carex Garberi Fern. — See Rhod. 37: 253–5 (1935). — On damp sandy or muddy shores and in muskegs on the eastern arm of Great Slave Lake. Not recorded elsewhere in the Mackenzie basin except on the Peace River just east of the mountains (under *C. Hassei* in Contr. Arn. Arb. 6: 33). — Great Slave L.: Keith Isl., no. 271; Fairchild Pt., nos. 272, 273.

Carex aurea Nutt. — Occasional on damp muddy or sandy shores or in rich woods, chiefly in the Paleozoic and younger country to the Mackenzie (*Richardson*, G). — “Isle a la Crosse to Methye Portage,” *Onion, Kennicott & Hardisty* (N); E. end of L. Athabaska, *Campbell*, no. 132423(O); Ft. Smith, no. 295.

Carex vaginata Tausch. — Common in muskeg thickets throughout most of the region northward to Great Bear Lake (*Richardson*, G). — Clearwater R., Sask., *J. M. Macoun*, no. 30704 (G, O) (the specimen in Gray Hb. is unnumbered, but is evidently a duplicate). Lake Athabaska: mouth of Charlot R., no. 6314; just south of Wabba L., N. of Cornwall Bay, no. 6486. Great Slave L.: Taltheilei Narrows, no. 266; Maufelly Pt., no. 268; Fairchild Pt., nos. 267, 269, 270. Last woods, E. shore of Artillery L., *Seton & Preble*, no. 87-c(O).

Carex capillaris L. — Common in muskeg thickets and damp crevices northward to the Mackenzie country (*Richardson*, G, N), and noted by Richardson at Great Bear Lake. — Lake Athabaska: near Sand Pt., no. 4645; Camsell Portage, nos. 6204, 6209; Charlot Pt., no. 6386. Great Slave L.: Maufelly Pt., no. 312; Fairchild Pt., nos. 313, 314, 315.

Carex Oederi Retz. var. *pumila* (Cosson & Germ.) Fern. — *C. viridula* Michx. — Apparently rare or occasional on damp shores in the pre-Cambrian country northward to Great Slave Lake. — Clearwater R., Sask., *J. M. Macoun*, no. 25479(O). Lake Athabaska: near Sand Pt., nos. 4488, 4644; rocky point at the N. W. entrance to Black Bay, no. 6419. Great Slave L.: Keith Isl., no. 305.

Carex abbreviata Prescott. — *C. Torreya* Tuckerm. — Apparently occasional northward in the Paleozoic and younger country to the Wood Buffalo Park, where it inhabits dry prairies. — Clearwater R., *J. M. Macoun*, no. 7458(G, O) (the specimen in Gray Hb. has no number but is of the same date and locality).

Carex lasiocarpa Ehrh. — Abundant on sandy pond and slough

margins on the south side of Lake Athabaska. Known elsewhere in the Mackenzie basin only by somewhat questionable records for closely related species. *Carex lanuginosa* was noted by Richardson at Methye Portage in 1845, and this record was apparently referred to *C. Houghtonii* in Macoun's Catalogue. There is a Richardson specimen of *C. Houghtonii* in Herb. O. marked "Cumberland House to Fort Chipe-wyan," but its actual locality is entirely uncertain. — Lake Athabaska: pond margin about 4 mi. S. E. of Wolverine Pt., no. 6785; pond margins about 5 mi. S. E. of Wolverine Pt., no. 6813; William Pt., no. 6853; about 2 mi. W. of Ennuyeuse Cr., no. 6993.

***Carex limosa* L.** — Occasional in wet muskegs northward at least to Great Slave Lake, chiefly in the pre-Cambrian country. — Lake Athabaska: near Sand Pt., no. 4482; along William R. near its mouth, no. 6862; muskeg about 3 mi. W. of Ennuyeuse Cr., no. 6972. Great Slave L.: Fairchild Pt., nos. 286, 287, 288.

***Carex paupercula* Michx. var. *irrigua* (Wahl.) Fern.** — Common in wet muskegs northward at least to Great Slave Lake. It appears to be most common in the pre-Cambrian country, but is also known in the Wood Buffalo Park. — Lake Athabaska: Shelter Pt., no. 327; 5 mi. E. of Poplar Pt., nos. 6658, 6671. Great Slave L.: Fairchild Pt., no. 328.

***Carex Parryana* Dewey.** — Known in the Mackenzie basin from a single collection on Great Slave Lake. — Taltheilei Narrows, no. 325.

***Carex VahlII* Schkuhr var. *inferalpina* (Wahl.) Fern.** — *C. Halleri* Gunn. — See Rhod. 35: 220-3, 398 (1933). — Occasional to common in muskeg thickets and damp prairie margins northward to Great Bear Lake (*Richardson*, G), but not thus far collected on Great Slave Lake. — Methye Portage, *J. M. Macoun*, no. 13408(O); Calumet, Athabaska R., no. 284. Lake Athabaska: Shelter Pt., no. 285; Sand Pt., nos. 4500, 4505; Camsell Portage, no. 6208; near mouth of Charlot R., no. 6350; W. shore of Ellis Bay, no. 6373.

***Carex atratiformis* Britton.** — Occasional in wet woods and thickets in the Wood Buffalo Park and southward, but not found thus far in the pre-Cambrian country or the lowlands bordering it.

***Carex Buxbaumii* Wahl.** — Occasional at the willow margins of prairie openings in the Wood Buffalo Park, and in damp crevices or sandy shores about Lake Athabaska, but not recorded elsewhere in the Mackenzie basin. — Lake Athabaska: Camsell Portage, no. 6206; mouth of Charlot R., nos. 6324, 6344; pond margin about 5 mi. S. E. of Wolverine Pt., no. 6812.

***Carex concolor* R. Br.** — *C. rigida* Good. — An arctic species known in the Mackenzie basin only in the margin of the timber. In

addition to the following it has also been collected at Great Bear Lake (*Richardson*, G, N). — Last woods, E. shore of Artillery L., *Seton & Preble*, no. 78295(O) (*C. rigida* of *Seton's* list).

***Carex lenticularis* Michx.** — Although noted in Fl. Bor.-Am. as occurring from "Canada to the Mackenzie River," this species has been very little collected east of the mountains. It was collected at Great Bear Lake by *Richardson* (G, N) and recorded by him at Methye Portage (1845), but otherwise the following is the only record for the Mackenzie basin. It grows on damp sandy beaches. — Shelter Pt., L. Athabaska, no. 318.

***Carex aquatilis* Wahl.** — One of the commonest sedges of sandy and marshy shores throughout the region and northward to the Arctic. It is extremely variable in form. — "Isle a la Crosse to Methye Portage," *Kennicott* (N); Methye Portage, *Richardson* (O); "between Lake Superior and Chipewyan," *Richardson* (O); Clearwater R., *J. M. Macoun*, no. 13414(O). Lake Athabaska: Shelter Pt., nos. 352, 353; Sand Pt., no. 4606; mouth of Charlot R., nos. 6323, 6349; small pond just N. of Cornwall Bay, no. 6628; 5 mi. E. of Poplar Pt., nos. 6660, 6676; along Archibald R., S. of Wolverine Pt., nos. 6728, 6739; about 4 mi. S. E. of Wolverine Pt., nos. 6776, 6786; William Pt., nos. 6847, 6877; wet places among dunes about 5 mi. S. of William Pt., no. 6891; about 2 mi. W. of Ennuyeuse Cr., nos. 6986, 7009. East shore of L. Mamawi, no. 1841; Peace R. delta, no. 338; upper Slave R. lowland, nos. 1842, 1847, 1848; Slave R. delta, nos. 340, 350. Great Slave L.: Keith Isl., no. 341; Taltheilei Narrows, no. 337; Fairchild Pt., nos. 342, 343, 344, 346, 347, 348, 351; Maufelly Pt., no. 339; Ft. Reliance, no. 345; island in Charlton Bay, no. 354; Yellowknife Bay, no. 349; N. W. shore, *Bedford* (O); Ft. Rae, *Bedford* (O).

***Carex trichocarpa* Muhl. var. *aristata* (R. Br.) Bailey.** — *C. atherodes* Spreng. — One of the most abundant sedges in the Paleozoic country, especially in the great river lowlands, but not found thus far in any part of the pre-Cambrian regions. Known also on the Mackenzie (*Richardson*, N). It occupies a variety of habitats ranging from lake shores, where it stands in water 4 feet deep, to nearly dry sloughs. — Lower delta of Athabaska R., nos. 317, 1857; E. shore of L. Mamawi, no. 1858; upper Slave R. lowland, nos. 1860, 1861, 1862; lower Slave R., no. 316.

***Carex physocarpa* Presl.** — An arctic species known in this region only on the north shore of Lake Athabaska where it grows in damp crevices on the shore. — Small island about 2 mi. E. of Crackingstone Pt., no. 6422; near base of Cornwall Bay, no. 6556.

Carex saxatilis L. — Known in our region from a single collection on Great Slave Lake, where it was found growing at the margin of a pond. The writer has seen no other Mackenzie basin specimens except one secured on the lower Mackenzie River by Dutilly (Herb. G.) — Fairchild Pt., no. 301.

Carex saxatilis L. var. **miliaris** (Michx.) Bailey. — Apparently rare, and thus far collected in the Mackenzie basin from a single locality on Lake Athabaska where it grows on sandy and stony shores. — Shelter Pt., nos. 319, 4437.

Carex Raeana Boott. — The type of this species was collected by Richardson at Methye Portage, but is otherwise unknown in the Mackenzie basin. The writer has not seen this type, but there is a Richardson specimen in Herb. O., without date or locality, which may be a part of it.

Carex membranopacta Bailey. — *C. membranacea* Hook. — *C. compacta* R. Br. — An arctic species entering our region only in the Lockhart basin and on Great Slave Lake, where it grows on rocky pond margins. It is also known at Great Bear Lake (*Richardson*). — Fairchild Pt., Great Slave L., no. 302; last woods, E. shore of Artillery L., *Seton & Preble*, no. 78296(O).

Carex rostrata Stokes. — An extremely common and variable species found at the margin of nearly every slough pond in the timbered regions, and extending northward to Great Bear Lake and the Mackenzie (*Richardson*, G, N). With *C. aquatilis* it makes up most of this type of vegetation. — Methye Portage, *Richardson*, no. 32037(O) (*C. utriculata* of *Richardson's* list of 1845, and of *Macoun's* Cat.), and *John Macoun*, no. 32032(O) (*C. utriculata* of *Macoun's* Cat.); Clearwater R., Sask., *J. M. Macoun*, July 17, 1888, no. 32034(O), and July 11, 1888(G). Lake Athabaska: Shelter Pt., no. 276; pond just N. of Cornwall Bay, no. 6629; along Archibald R., near its mouth, no. 6765; William Pt., nos. 6846, 6850, 6866; about 3 mi. W. of Ennuyeuse Cr., no. 6966; about 2 mi. W. of Ennuyeuse Cr., no. 7001. Lower delta of Athabaska R., no. 1828; upper Slave R. lowland, nos. 1830, 1834, 1838; lower Slave R., nos. 274, 277, 278, 281. Great Slave L.: Fairchild Pt., nos. 275, 280; Yellowknife Bay, no. 279; N. W. shore, *Bedford* (O).

Carex retrorsa Schwein. — Known in this region only in the southwestern part of the Wood Buffalo Park, along the Peace River.

Carex oligosperma Michx. — Common on sandy pond margins on the south side of Lake Athabaska, and known also at the widely separated localities — Methye Portage (*John Macoun*), and Great Bear

Lake (*Richardson*, G). Otherwise it is not known in the Mackenzie basin. — Methye Portage, *John Macoun*, no. 31548(O). Lake Athabaska: about 4 mi. S. E. of Wolverine Pt., no. 6777; about 5 mi. S. E. of Wolverine Pt., no. 6814; William Pt., no. 6852.

ARACEAE

***Calla palustris* L.** — Occasional in muskeg and flood plain sloughs northward at least to Great Slave Lake. — Delta of the Athabaska R. (Mamawi Cr.), no. 1994. Lake Athabaska: Shelter Pt., nos. 394, 395, 4419; 5 mi. E. of Poplar Pt., no. 6674. Upper Slave R. lowland, no. 1993. Great Slave L.: S. W. and N. shores, *Howe*, no. 91988(O); N. W. shore, *Bédford* (O).

LEMNACEAE

***Lemna minor* L.** — Probably common in slough ponds throughout most of the region northward at least to Great Slave Lake, but very little collected. — Muskeg pond N. of Cornwall Bay, L. Athabaska, no. 6499; upper Slave R. lowland, no. 394-a; Yellowknife Bay, Great Slave L.

***Lemna trisulca* L.** — Abundant in a slough pond in the Murdock Creek district, west of the upper Slave River. There are no other well-authenticated records for the Mackenzie basin, although there is a *Richardson* specimen in Herb. O. marked "From Cumberland House to Fort Chipewyan, June-July, 1820." It was collected by J. M. Macoun on Methye River in 1888, no. 28117(O), and is probably widespread at least in the southern part of the region. — Upper Slave R. lowland, no. 1995.

JUNCACEAE

***Juncus bufonius* L.** — Noted in Fl. Bor.-Am. as occurring northward to Great Bear Lake, but the writer has seen no material from beyond the Wood Buffalo Park. It is occasional on damp slough margins, sandy lake shores, and in rock crevices, apparently not extending far into the pre-Cambrian country. — Lake Athabaska: Chipewyan, no. 4695; Shelter Pt., no. 407; along Ennuyeuse Cr., near its mouth, no. 6928. Granite hill on W. shore of L. Mamawi, no. 2009.

***Juncus bufonius* L. var. *halophilus* Buchenau & Fern.** — Known in the Mackenzie basin only from the south side of Lake Athabaska, where it was growing on a wet river sand bar. — William R. near its mouth, no. 6871.

***Juncus Dudleyi* Wieg.** — Known in the Mackenzie basin from a single locality. — Damp slough at Chipewyan, L. Athabaska, nos. 4691, 7019.

Juncus Vaseyi Engelm. — Common at upland slough margins and on damp sandy plains and shores northward at least to Lake Athabaska and the Wood Buffalo Park. — Lake Athabaska: Chipewyan, nos. 7018, 7044; Shelter Pt., nos. 411, 412, 4440; Sand Pt., nos. 4553, 4655; rocky point at N. W. entrance to Black Bay, no. 6414; pond margins about 5 mi. S. E. of Wolverine Pt., no. 6817.

Juncus arcticus Willd. — An arctic and alpine species, common on sandy and muddy shores about the eastern arm of Great Slave Lake, but not thus far collected elsewhere in this region (see note under *J. balticus* var. *littoralis*). — Great Slave L.: Keith Isl., no. 414; Talthelei Narrows, no. 421; Fairchild Pt., nos. 420, 422, 423; base of Maufelly Pt., no. 413; Ft. Reliance, nos. 418, 419.

Juncus balticus Willd. var. *littoralis* Engelm. — Common on muddy and sandy shores northward in the great river lowlands to the lower Mackenzie (Miss E. Taylor, O). It is abundant about Lake Athabaska and on the Salt Plains, but on Great Slave Lake its place is largely taken by *J. arcticus*. Part of the Athabaska Lake material cited below (nos. 6772, 6892) appears to be intermediate between this species and *J. arcticus*. It has the inflorescences of *J. balticus littoralis*, but the capsules are nearly black and mature longer than the sepals as in *J. arcticus*. — Methye Portage, *J. M. Macoun*, no. 27802 (O); Calumet, Athabaska R., no. 415. Lake Athabaska: Shelter Pt., nos. 416, 417; Sand Pt., no. 4567; N. shore of Ellis Bay, no. 6171; mouth of Charlot R., nos. 6328, 6330; Cornwall Bay, no. 6609; mouth of Archibald R., no. 6772; wet places among dunes about 5 mi. S. of William Pt., no. 6892; among dunes just E. of Ennuyeuse Cr., no. 6906. Upper Slave R. lowland, no. 2004; Slave R., *Richardson* (G) (*J. balticus* in Fl. Bor.-Am.).

Juncus filiformis L. — Apparently occasional northward to Lake Athabaska and the Wood Buffalo Park, on wet stony-sandy shores and plains. Noted in Fl. Bor.-Am. as extending to Great Bear Lake. — Lake Athabaska: Shelter Pt., nos. 410, 4438; Sand Pt., no. 4551; along Archibald R., S. of Wolverine Pt., no. 6727; mouth of Archibald R., no. 6754; damp places among dunes about 5 mi. S. of William Pt., no. 6895-a.

Juncus brevicaudatus (Engelm.) Fern. — Abundant on wet sandy shores, chiefly of ponds and beach lagoons, about Lake Athabaska, but not known elsewhere in the Mackenzie basin. — Lake Athabaska: Shelter Pt., no. 4424; Sand Pt., no. 4552; ponds about 5 mi. S. E. of Wolverine Pt., nos. 6830, 6832; William Pt., nos. 6851, 6863, 6870; small pond among big dunes about 5 mi. S. of William Pt., no. 6881;

along Ennuyeuse Cr. near its mouth, no. 6928-a; about 2 mi. W. of Ennuyeuse Cr., no. 6981.

Juncus nodosus L. — Common on wet sandy or muddy shores northward mainly in the Paleozoic and younger country, and reaching to the Mackenzie R. (*Onion*, N). In Fl. Bor.-Am., as *J. polycephalus* var. *tenuifolius*, it is noted at Great Bear Lake. — McMurray, no. 7062; lower delta of Athabaska R., no. 408; Shelter Pt., L. Athabaska, no. 409; upper Slave R. lowland, no. 2007; Ft. Smith, *Russell*, no. 28(O).

Juncus alpinus Vill. — Occasional on wet sandy or muddy shores, mainly in the pre-Cambrian country. — Lake Athabaska: Shelter Pt., no. 402; near Sand Pt., no. 4634. Lower delta of the Peace R., no. 401. Great Slave L.: Keith Isl., no. 405; Maufelly Pt., no. 406; Fairchild Pt., nos. 403, 404.

Juncus alpinus Vill. var. *rariflorus* (Hartm.) Hartm. — *J. alpinus* Vill. var. *insignis* Fries. — *J. Richardsonianus* Schultes. — See Botaniska Notiser, 1932: 313-72, and Rhod. 35: 233-34 (1933). — Occasional on damp muddy shores, with a range in this region not unlike that of the species. Known also on the Mackenzie (*Richardson* ?, G; *Onion*, N). — Lake Athabaska: Chipewyan, no. 4699; Sand Pt., no. 4564. Upper Slave R. lowland, no. 1999. Great Slave L., *Richardson* ? (G) (*J. acutiflorus* in Fl. Bor.-Am., in part).

Juncus albescens (Lange) Fern. — *J. triglumis* L. var. *albescens* Lange. — See Rhod. 26: 201-3 (1924). — Known in the Mackenzie basin only at the eastern end of Great Slave Lake where it was growing in a limey upland swamp. — Fairchild Pt., no. 396.

Juncus stygius L. var. *americanus* Buchenau. — Collected thus far in the Mackenzie basin from a single locality on the south side of Lake Athabaska. — Wet slough on William Pt., no. 6869.

Juncus castaneus Smith. — An arctic and alpine species, occasional or common in muskegs or on wet sandy and gravelly shores southward in this region to the lower Athabaska River. It is frequent about Great Slave Lake, but has not yet been collected on Lake Athabaska nor in the Wood Buffalo Park. — Calumet, Athabaska R., no. 397. Great Slave L.: Taltheilei Narrows, no. 398; Fairchild Pt., nos. 399, 400.

Luzula confusa Lindeb. — *L. hyperborea* R. Br., in part. — An arctic species known in the Mackenzie basin from a single collection northeast of Great Slave Lake. — Last woods, E. shore of Artillery L., *Seton & Preble*, no. 78927(O).

Luzula campestris (L.) DC. var. *alpina* Gaud. — *L. sudetica* Willd. — Apparently rare in the Mackenzie basin, and known only from Great Slave and Great Bear (*J. M. Bell*, O) Lakes not far south

of the margin of the timber. — Taltheilei Narrows, Great Slave L., no. 424.

LILIACEAE

Tofieldia palustris Huds. — Common in muskegs in the more arctic parts of the pre-Cambrian country, and northward. — Lake Athabaska: near Sand Pt., no. 4626. Great Slave L.: Taltheilei Narrows, no. 425; base of Maufelly Pt., no. 428; Fairchild Pt., nos. 426, 427, 429, 430, 431; S. W. and N. shores, *Howe*, no. 91987(O); N. W. shore, *Bedford* (O).

Tofieldia glutinosa (Michx.) Pers. — See Contr. Arn. Arb. 6:137 (1934). — Noted in Fl. Bor.-Am. as occurring "throughout Canada, to . . . Bear Lake," and there is a Richardson specimen in Herb. G. labeled "Cumberland House to Bear Lake." Otherwise unknown in the Mackenzie basin east of the mountains except for a single specimen from an upland muskeg west of the Slave River, in the Wood Buffalo Park.

Zygadenus elegans Pursh. — *Anticlea elegans* (Pursh) Rydb. — See Rhod. 37: 256-8 (1935). — A species of the northern plains and mountains, extending northward in the Paleozoic country to the lower Mackenzie (*Miss E. Taylor*, G, N), and Bear Lake (*Richardson*, G). — Great Slave L.: S. W. and N. shores, *Howe*, nos. 91986, 91985(O); Windy Pt., *Hume*, no. 102657(O); N. W. shore, *Bedford* (O); Old Fort Rae, *Russell* (O).

Allium Schoenoprasum L. var. **sibiricum** (L.) Hartm. — *A. sibiricum* L. — Occasional on damp sandy or gravelly shores and in rock crevices; widely distributed throughout the Mackenzie basin, but mostly in the Paleozoic or younger country. — Lake Athabaska: Shelter Pt., no. 435; Charlot Pt. and vicinity, nos. 6229, 6242, 6380; N. shore, *J. W. Tyrrell*, no. 27419(O). Great Slave L.: N. W. shore, *Bedford* (O); "Carlton House to Slave Lake," *Richardson* (G) (*A. Schoenoprasum* in Fl. Bor.-Am. and Macoun's Cat.).

Lilium philadelphicum L. var. **andinum** (Nutt.) Ker. — Apparently limited to the southern parts of the Mackenzie basin, and known in our region only on the lower Athabaska River. — McMurray, no. 7115; Calumet, no. 435.

Smilacina stellata (L.) Desf. — *Vagnera stellata* (L.) Morong. — Rather common in thickets and semi-open prairies northward in the Paleozoic or younger country to the Wood Buffalo Park. — Granite hill on E. shore of L. Mamawi, nos. 2016, 4411.

Smilacina trifolia (L.) Desf. — *Vagnera trifolia* (L.) Morong. — Common in wet muskegs, where it usually grows on hummocks of

Sphagnum and other mosses. Noted in Fl. Bor.-Am. as extending northward to Great Bear Lake but the writer has seen no material from beyond the south shore of Great Slave Lake. — Lake Athabaska: Shelter Pt., nos. 432, 433; Sand Pt., no. 4532; 5 mi. E. of Poplar Pt., no. 6665; 2 mi. W. of Ennuyeuse Cr., no. 7011; "From Cumberland House to Fort Chepewyan," *Richardson*, no. 27609(O). Resolution, *Kennicott* (N).

Maianthemum canadense Desf. var. *interius* Fern. — *Unifolium canadense* (Desf.) Greene var. *interius* (Fern.) House. — See Rhod. 16: 211 (1914). — Abundant in woods northward to Lake Athabaska and the Wood Buffalo Park. Although known on the Mackenzie (*Miss E. Taylor*, N) and noted in Fl. Bor.-Am. at Great Bear Lake, it has not been collected on Great Slave Lake. — Calumet, Athabaska R., no. 439. Lake Athabaska: Shelter Pt., nos. 437, 438, 440, 442; Sand Pt., no. 4650; near tip of Elliot Pt., no. 6427; 5 mi. E. of Poplar Pt., no. 6687; along Archibald R. near its mouth, no. 6763; 2 mi. W. of Ennuyeuse Cr., no. 6936; N. shore, *J. W. Tyrrell*, no. 116237(O). Upper delta of Peace R. (Quatre Fourches R.), no. 441; Ft. Smith, no. 436; and *Miss E. Taylor*, no. 27537(O); and *Seton & Preble*, no. 78569(O).

Disporum trachycarpum (Wats.) Benth. — Common in upland, rather open woods in the southern parts of the Mackenzie basin, but not known north of the lower Athabaska. — Lac la Biche, no. 2021; Waterways, no. 2022; McMurray, no. 7110; along the Firebag R. near its mouth, no. 6044.

IRIDACEAE

Sisyrinchium angustifolium Miller. — Common in dry prairie openings, rock crevices, and on stony or sandy lake shores northward to Lake Athabaska and the Wood Buffalo Park. It is known on the upper Mackenzie (*Miss E. Taylor*, O), but has not yet been recorded on Great Slave Lake. — Calumet, Athabaska R., no. 444. Lake Athabaska: Chipewyan, *Laing*, no. 63(N); Shelter Pt., nos. 443, 445; Sand Pt., no. 4632; small island at base of Charlot Pt., no. 6378; mouth of Charlot R., no. 6326; Fishhook Bay, no. 6586; Cornwall Bay, no. 6606.

ORCHIDACEAE

Cypripedium passerinum Richards. — See Trans. Roy. Soc. Can. ser. 3, sect. 5, 22: 163-172 (1928). — Occasional in rather dry woods throughout most of the timbered country, north to the Mackenzie (*Miss E. Taylor*, G, N, O; *R. M. Anderson*, N). Although widely distributed about Great Slave Lake it has not been found on Lake Athabaska. — Lower Slave R., no. 469. Great Slave L.: Maufelly Pt., no. 470; Fairchild Pt., no. 471; N. W. shore, *Bedford* (O).

Cypripedium guttatum Swartz. — A species of far-northwestern affinity, known in our region only on Great Slave Lake. — Great Slave L.: *R. Bell*, no. 23156(O); Maufelly Pt., no. 468; Old Fort Rae, *Russell* (O).

Cypripedium acaule Ait. — Common on dry sandy plains and ridges about Lake Athabaska, but not known elsewhere in the Mackenzie basin except on Great Bear Lake (*Richardson*, G). — Lake Athabaska: Sand Pt., nos. 4471, 4486, 4601, 4656; 5 mi. E. of Poplar Pt., no. 6636; 2 mi. E. of Wolverine Pt., no. 6800; pine woods among dunes just E. of Ennuyeuse Cr., no. 6917.

Orchis rotundifolia Pursh. — Rather common in timbered muskegs northward at least to Great Slave Lake. — Calumet, Athabaska R., no. 478. Lake Athabaska: muskeg N. W. of Cornwall Bay, no. 6515. Ft. Smith and vicinity, no. 475; and *Miss E. Taylor* (G, N, O). Great Slave L.: *Onion* (N); Keith Isl., no. 479; Maufelly Pt., no. 477; Fairchild Pt., nos. 476, 480, 481; Windy Pt., *Hume* (O); N. W. shore, *Bedford* (O); Old Fort Rae, *Russell* (O).

Habenaria viridis (L.) R. Br. var. **bracteata** (Willd.) Gray. — *Coeloglossum bracteatum* (Willd.) Parl. — Occasional in dry upland woods and thickets northward in the Paleozoic and younger country at least to the Wood Buffalo Park. — Calumet, Athabaska R., no. 458.

Habenaria hyperborea (L.) R. Br. — *Limnorchis hyperborea* (L.) Rydb. — Rather common in muskegs northward to Great Slave Lake, chiefly in the Paleozoic country. Noted in Fl. Bor.-Am. as occurring at Great Bear Lake. — Lower Athabaska (Elk) R., *Kennicott* (N). Lake Athabaska: Shelter Pt., no. 447; muskeg N. W. of Cornwall Bay, no. 6515. Great Slave L.: *Onion*, *Kennicott & Hardisty* (N); N. W. shore, *Bedford* (O).

Habenaria obtusata (Pursh) Richardson. — *Lysiella obtusata* (Pursh) Rydb. — Abundant in rich woods and timbered muskegs northward to Great Slave Lake, and known also at Great Bear Lake (*J. M. Bell*, O). — Calumet, Athabaska R., no. 457. Lake Athabaska: Shelter Pt., no. 455; Charlot Pt., no. 6226; muskeg S. of Wabba L., no. 6487. Fort Smith and vicinity, no. 451; and *Miss E. Taylor* (G, N, O); lower Slave R., no. 449. Great Slave L.: Resolution, *Kennicott* (N); Keith Isl., no. 456; Maufelly Pt., no. 448; Fairchild Pt., nos. 452, 453, 454; Yellowknife Bay, no. 450; N. W. shore, *Bedford* (O); Windy Pt., *Hume*, no. 102658(O); S. W. and N. shores, *Howe*, no. 91984(O).

Spiranthes Romanzoffiana Cham. — *Ibidium Romanzoffianum* (Cham.) House. — Occasional or common in timbered muskegs northward to Great Slave Lake, and noted in Fl. Bor.-Am. at Fort Frank-

lin. — Lower Athabaska (Elk) R., *Kennicott* (N). Lake Athabaska: Shelter Pt., no. 466; near Sand Pt., no. 4535; N. of Cornwall Bay, no. 6479; muskeg N. W. of Cornwall Bay, no. 6527; about 5 mi. S. E. of Wolverine Pt., no. 6815. Upper Slave R. lowland, no. 2073; near upper Smith Rapids, no. 465. Great Slave L.: R. *Bell*, no. 23155(O); *Onion*, *Kennicott & Hardisty* (N); Maufelly Pt., no. 462; Fairchild Pt., nos. 463, 464; Ft. Rae, *Russell* (O).

Goodyera repens (L.) R. Br. var. *ophioides* Fern. — *Peramium ophioides* (Fern.) Rydb. — *Epipactis repens* (L.) Crantz var. *ophioides* (Fern.) A. A. Eat. — See Contr. Arn. Arb. 6: 141 (1934). — Noted in Fl. Bor.-Am. as occurring northward to Fort Franklin, but the writer has seen no specimens from beyond the Wood Buffalo Park where it is rare or occasional in rich woods. On sandy beach ridges about Lake Athabaska, however, it becomes exceedingly abundant, particularly on the south shore. — Lake Athabaska: Shelter Pt., no. 467; Sand Pt., nos. 4476, 4559; Cornwall Bay, no. 6635; about 2 mi. E. of Wolverine Pt., no. 6796; about 2 mi. W. Ennuyeuse Cr., no. 6935.

Listera borealis Morong. — *Ophrys borealis* (Morong) Rydb. — Rare or occasional in timbered muskegs northward in the Paleozoic and younger country to the upper Mackenzie (*Kennicott?*, N). — Calumet, Athabaska R., no. 459; Ft. Smith, no. 460; and *Miss E. Taylor* (N, O).

Calypso bulbosa (L.) Oakes. — *C. borealis* Salisb. — *Cytherea bulbosa* (L.) House. — Common to abundant in the pre-Cambrian country northward to Great Bear Lake, but rather occasional in the Paleozoic regions. It grows in rich woods and thickets. — Along the Firebag R. near its mouth, no. 6016. Lake Athabaska: Chipewyan, *Miss E. Taylor* (O); Charlot Pt., no. 6082; Turnor Pt., no. 6842. Great Slave L.: Resolution, *Kennicott* (N); Fairchild Pt., no. 461. "Between Forts Simpson and Chipewyan," *Richardson* (O).

Corallorrhiza trifida Chat. — *C. Corallorrhiza* (L.) Karst. — Occasional in rich woods and timbered muskegs northward at least to Great Slave Lake. — Along Firebag R. near its mouth, no. 6019. Lake Athabaska: Charlot Pt., nos. 6107, 6158; hills N. W. of Cornwall Bay, no. 6528. East shore of L. Mamawi, no. 2037; Forth Smith district, *Miss E. Taylor* (G, O). Great Slave L.: Resolution, *Kennicott* (N); Fairchild Pt., nos. 472, 473.

SALICACEAE

Populus tremuloides Michx. — Common to abundant throughout the forested region nearly to timber line, mainly on dry upland soils. About the eastern arm of Great Slave Lake it is a gnarled and twisted shrub, but farther south, as in the Wood Buffalo Park, it is a large tree

often forming nearly pure stands in burned-over country. — Calumet, Athabaska R., no. 485. Lake Athabaska: Shelter Pt., nos. 483, 484; Charlot Pt., no. 6212; sand hills about 4 mi. S. E. of Wolverine Pt., no. 6787. Upper Slave R. lowland, no. 482; Ft. Smith, no. 489. Great Slave L., Taltheilei Narrows, no. 487.

Populus tacamahacca Miller. — *P. balsamifera* DuRoi, not L. — See Jour. Arn. Arb. 10: 55 (1929). — Abundant on the great river flood plains throughout the wooded districts. Northeastward it extends as a stunted tree nearly to timber line, occupying sandy or gravelly lake beaches. In the uplands of the Wood Buffalo Park it is associated with the aspen in burned-over areas, forming part of the transition timber between aspen and spruce. — Calumet, Athabaska R., no. 490. Lake Athabaska: Shelter Pt., no. 491; Charlot Pt., no. 6212; bank of Archibald R. near its mouth, no. 6766. Peace R. delta, nos. 493, 494; upper Slave R. lowland, no. 495; Ft. Smith, no. 497. Great Slave L.: Resolution, J. W. Tyrrell, no. 23132 (O); Fairchild Pt., no. 492; Ft. Reliance, no. 496; N. W. shore, Bedford (O). Artillery L., J. W. Tyrrell (O).

Salix serissima Fern. — Known in the Mackenzie basin from two collections, one near Lesser Slave Lake (*Brinkman*), and the other from the north shore of Lake Athabaska. The latter was found with nearly mature aments in the last week of June, whereas *S. serissima* of the eastern part of the continent is known for its late flowering — "late August-October." In morphological characters, however, it seems a good match for typical *S. serissima*. See note under *S. lasiandra*. — Charlot R., near its entrance to Lake Athabaska, no. 6353.

Salix lasiandra Benth. — See Jour. Arnold Arb. 1: 14-20 (1919); Bot. Gaz. 72: 220-36 (1921); Can. Field Nat. 40: 145-50 (1926). — Rather common in the lowland flood plain and delta districts northward to the upper Mackenzie (*Dutilly*, G), with a very short extension into the pre-Cambrian country on Lake Athabaska where it grows on damp sandy lake beaches. It was noted in Fl. Bor.-Am. (under *S. lucida*) as reaching northward to Fort Franklin. Flowers collected early in June and mature fruit in August.

The writer has already discussed part of this material in its relation to *S. serissima* Fern. (Contr. Arnold Arb. 6: 142-3). Most of it appears to be good *lasiandra*, but certain specimens from the east shore of Lake Mamawi seem intermediate between the two. Ball has cited certain Laing specimens from the Athabaska delta under *S. caudata* (*S. lasiandra* var. *caudata* Sudw.), and a Kennicott specimen from the Slave River under *S. serissima*. The writer has been unable to distinguish var. *caudata* in any of his own material, and Ball was apparently doubt-

ful about the Laing specimens due to their immaturity. Consequently these citations have been placed here provisionally, as well as those questionably determined as *S. serissima*. — Grand Rapids, Athabaska R., *Harper*, no. 99036(O); along lower Firebag R., near its mouth, nos. 6029, 6030, 6031; Athabaska delta, main branch, *Laing*, nos. 33, 51 (Herb. Ball, and W.) (N. E.¹). Lake Athabaska: Shelter Pt., nos. 559, 4448; Sand Pt., no. 4581. East shore of L. Mamawi, nos. 2084, 4406; upper Slave R. lowland, no. 560; Slave R., *Kennicott* (W) (N. E.).

SALIX FRAGILIS L. — An introduced species known only in the southern part of the Mackenzie basin. — Bank of Athabaska R. at Athabaska Landing, *Ball*, no. 116493(O).

Salix interior Rowlee. — See Can. Field Nat. **40**: 174–5 (1926). — Most of the collections of the sand bar willow from our region seem to fall into the narrow-leaved variety *pedicellata*, but occasionally the typical form appears. Thus far it is known only from the Slave River lowland. — Lower delta of Slave R., no. 561.

Salix interior Rowlee var. *pedicellata* (Anders.) Ball. — *S. linearifolia* Rydb. — See Bot. Gaz. **67**: 344 (1919), and Can. Field Nat. **40**: 175 (1926). — Abundant on sand bars in the great river lowlands northward to Great Slave Lake, and probably also to the Mackenzie. — Calumet, Athabaska R., no. 562; along the Firebag R. near its mouth, no. 6012; delta of Athabaska R., no. 566; and *Harper*, no. 99035(O); Sand Pt., L. Athabaska, no. 4563; E. shore of L. Mamawi, no. 2086; delta of Peace R., nos. 564, 565; upper Slave R. lowland, no. 563; lower Slave R., near Grande Detour, *Harper*, nos. 99019, 99025(O); Slave R., *Kennicott* (N); between Forts Simpson and Chipewyan, *Richardson* (O) (*S. longifolia* of Fl. Bor.-Am. and Macoun's Cat., at least in part). — In his revision of this group (Can. Field Nat. loc. cit.) Ball cites the following specimens not thus far examined by the writer. Under *S. interior*; Ft. McMurray, *E. A. and A. E. Preble*, no. 81; and under var. *pedicellata*: Athabaska delta, *Laing*, nos. 42, 49 (Herb. Ball).

Salix reticulata L. — An arctic species which enters our region only in exposed situations not far from the timber line. — Great Slave L.: Taltheilei Narrows, no. 572; Maufelly Pt., no. 571; Fairchild Pt., no.

¹During the time this study has been in progress a considerable number of northern specimens of *Salix* have been away from Herb. O. on loan, and consequently have not been seen by the writer. In most cases it has seemed advisable to include these as well as a few citations of Schneider and Ball material for future reference, and wherever they have been inserted the letters "N. E." (not examined) immediately follow. It should be noted that most of the determinations of such specimens are those of either Schneider or Ball, both recent students of American willows who have had access to the collection.

570; Caribou Isl., *Seton & Preble*, no. 78303(O) (N. E.). Artillery L., *Seton & Preble*, no. 78304(O) (N. E.).

Salix arctica Pallas. — See Bot. Gaz. 66: 118 (1918). — A north-western arctic species apparently rare in our region, and known only in the pre-Cambrian country. The Chipewyan specimen was found in good fruit sometime between June 17 and July 21, presumably soon after the first date. — Chipewyan, L. Athabaska, *Dutilly*, no. 148(G); Artillery L., *J. W. Tyrrell*, no. 23120(O) (N. E.).

Salix arctophila Cock. — *S. groenlandica* Lundström. — See Bot. Gaz. 66: 140 (1918), and 67: 57 (1919). — Occasional on exposed shores at least in the northern part of the pre-Cambrian country. — North shore of McLeod Bay, Great Slave L., nos. 546, 547. The following specimens are cited here provisionally, since the group to which they belong is notably difficult: N. shore of L. Athabaska, *J. W. Tyrrell*, no. 1703(O) (N. E., probably *S. Brownii* of Tyrrell's list); Ft. Resolution, *J. W. Tyrrell*, no. 23128(O) (N. E.); Artillery L., *J. W. Tyrrell*, no. 23127(O) (N. E., probably *S. Brownii* of Tyrrell's list), and *Seton & Preble*, no. 78301(O) (N. E.).

Salix brachycarpa Nutt. var. *antimima* (Schn.) Raup. — See Rhod. 33: 241-4 (1931). — Known in the Mackenzie basin east of the mountains only in the Wood Buffalo Park.

Salix brachycarpa Nutt. var. *psammophila*, var. nov. PLATE 191¹

A *S. brachycarpa* differt habitu stricto erecto (9-12 dm. alto), foliis late ovatis (rarius obovatis), plerisque 1×2 cm., basi rotundatis ad subcordatis, dense albo-sericeis.

Among inland shifting sand dunes south of William Pt., south shore of Lake Athabaska, Sask., Aug. 16, 1935, no. 6888 (Type, A). Another number (no. 6902) which matches the type was collected in the same dune area, about 4 miles farther west, on Aug. 20, 1935.

This material, with its woolly, nearly sessile capsules, short styles, pale bracts, and aments borne on leafy peduncles, clearly belongs to the group of polymorphic and largely intergrading species centering about the circumpolar *S. glauca* L. Within this group it is closely related to the predominantly western American complex distinguished by its short, ovate-oblong to nearly spherical aments, for which the oldest name is *S. brachycarpa* Nuttall. Nothing in this complex, however (*S. pseudo-lapponicum* v. Seeman, *S. brachycarpa* var. *antimima* (Schn.) Raup, *S.*

¹PLATE 191. *Salix brachycarpa* Nutt. var. *psammophila* Raup. Details are part of type collection from sand dunes about 5 miles south of William Pt., Lake Athabaska, no. 6888; detail of ament $\times 2$; habit photo taken on same dune area, just east of Ennuyeuse Creek, August 20, 1935.

niphoclada Rydb., etc.), has the broadly ovate leaves or strict, upright habit of our plants. Certain eastern representatives of the group collected on Mt. Albert in the Gaspé region (Fernald & Collins, nos. 65 and 513, distributed as *S. desertorum* var. *stricta*) show a tendency toward broad leaves on young shoots, but the tendency is not consistent, nor are the leaves so heavily clothed with long hairs, and the plants are low, depressed shrubs like most of the relatives of *S. brachycarpa*.

Salix desertorum Richards. — See Rhod. 33: 241-4 (1931). — Apparently rare, and confined to exposed situations near timber line or in the scrubby woodlands of the pre-Cambrian regions. It is the writer's opinion that *S. desertorum* may be only a dwarfed form of the woodland *S. glauca* growing in bleak, exposed situations or cold upland bogs. — Taltheilei Narrows, Great Slave L., no. 534. — Schneider (Bot. Gaz. 66: 340) provisionally referred to this species a specimen collected on Artillery Lake by Seton & Preble, no. 78300(O) (N. E.). This appears to have been originally determined *S. niphoclada* Rydb. by J. M. Macoun and later verified as such by Ball. Another Tyrrell specimen may also be placed here provisionally: Lake Athabaska, J. W. Tyrrell, no. 1710(O) (N. E.).

Salix MacCalliana Rowlee. — Common in parts of the Wood Buffalo Park, especially on the Salt Plain, but not known elsewhere in our region.

Salix Tyrrellii, sp. nov.

PLATE 192¹

Frutex patulus, ad 2 m. altus, cortice rubescente lucido, ramulis rubescentibus glabris etiam novellis; folia matura 2-3.5 cm. longa, 4-8 mm. lata, lanceolata ad elliptica, rarius oblanceolata, basi acuta, apice acuta ad acuminata, utrinque nitido-viridia, saepe supra lucida, paulo coriacea, inaequaliter et minute sed conspicue serrata dentibus glandulosis plerumque 2-3 per 5 mm., rarius 4 per 5 mm.; petioli 2-6 mm. longi, basi rubescentes; stipulae non persistentes, rubescentes, ovatae ad lanceolatae, serratae, acutae, 1-2 mm. longae. Amenta feminea (immatura) 1-2.5 cm. longa, circa 8 mm. lata, pedunculo brevi foliato suffulta; capsula dense albo-hirsuta, 3-4 mm. longa, fere sessilia vel pedicello quam 1 mm. brevior; styli 2-2.5 mm. longi, rubro-fulvi, stigmatibus circa 3 mm. longis bifidis; bractee circa 3 mm. longae, basi 0.5 mm. latae, anguste lanceolatae, acutae, basi rubro-fulvae apicem versus flavescens, albo-hirsuto-pubescentes, apice glabratae, venosae; glandula (immatura tandem) ventralis tantum adest, ut videtur e glandulis

¹PLATE 192. *Salix Tyrrellii* Raup. Part of type collection from shifting sand dunes about 5 miles south of William Pt., Lake Athabaska, no. 6887; details of leaf and ament $\times 2$.

binis parvis paulo supra basin pedicelli insertis composita.

Among inland shifting sand dunes south of William Pt., south shore of Lake Athabaska, Sask., Aug. 16, 1935, no. 6887 (Type, A). A sterile specimen, no. 6903, was collected from the same dune area, but about 4 miles farther west, on Aug. 20, 1935.

With its pubescent, short-pedicelled capsules, long, reddish to yellowish bracts, divided stigmas, and aments borne on short leafy peduncles, *S. Tyrrellii* evidently belongs to the section *GLAUCAE* of Fries, but beyond these characters the relationship does not go, with a possible exception in the case of *S. MacCalliana* Rowlee. This anomolous species also possesses entirely glabrous, distinctly serrate leaves, but has ament characters which clearly relate it to *S. glauca*. The leaves of *S. MacCalliana* are rather bluish-green, and tend to be crenate-dentate, and commonly 6 or more cm. long, whereas in our plant they are much smaller, bright green, with salient glandular teeth which are fewer in number than in *S. MacCalliana* (usually 2–3 per 5 mm., as against 3–4 per 5 mm.). The apex is consistently acute or acuminate, rather than subacute as in *S. MacCalliana*, and the leaves are but rarely oblanceolate, while they are commonly so in the latter species. In our plant the styles are 2–2.5 mm. long, while in *S. MacCalliana* they are 0.8–1.3 mm. long. *Salix Tyrrellii* is named for the distinguished Canadian geologist, J. W. Tyrrell, who, in 1893, made the first notable plant collections from Lake Athabaska.

***Salix glauca* L.** — See Rhod. 33: 241–4 (1931). — Rather common throughout most of the region, growing in muskeg thickets and open muskeg timber, or at the borders of rich woods. It varies widely in leaf form and pubescence, and in the form and size of the shrub, but its division into more than one specific entity seems unjustifiable. Of the specimens cited below, nos. 6461, 6462, 6463 are especially notable because of their short broad leaves which somewhat resemble those of *S. cordifolia*. The latter is not thus far known in the Mackenzie basin. — Lake Athabaska: Shelter Pt., nos. 523, 4420; Camsell Portage, nos. 6178, 6181, 6184, 6185, 6186, 6196; along Charlot R., near its entrance to L. Athabaska, no. 6354; near base of Cornwall Bay, nos. 6459, 6461, 6462, 6463, 6513, 6514. Rocher R., below L. Athabaska, *Harper*, no. 99037(O); upper Slave R. lowland, no. 6129. Great Slave L.: Talttheilei Narrows, no. 521; Fairchild Pt., no. 524; N. W. shore ?, *Bedford* (O).

***Salix glauca* L. var. *acutifolia* Schn.** — See Bot. Gaz. 66: 327 (1918), and 67: 60 (1919); Rhod. 33: 241–4 (1931). — Common in muskegs and on damp lake shores in the pre-Cambrian parts of our region, but known also from Great Bear Lake and the Mackenzie River

(*Richardson*, N). — Lake Athabaska: near Sand Pt., nos. 4507, 4517, 4518, 4528; Camsell Portage, no. 6182; Charlot Pt., nos. 6223, 6297; along Charlot R. near its mouth, nos. 6355, 6356, 6357; near base of Cornwall Bay, nos. 6458, 6459-a, 6460, 6569. Great Slave L.: near Caribou Isl., *Seton & Preble*, no. 78305(O) (N. E.; *S. atra* of Seton's list; placed here provisionally by Schneider); Fairchild Pt., nos. 576?, 528, 532, 533; Maufelly Pt., no. 531; Yellowknife Bay, no. 530.

Salix glauca* L. var. *poliophylla* (Schn.), status nov.** — In his monographic studies of American willows, Schneider described a forma *poliophylla* of *Salix glauca* L. var. *acutifolia* Schn. (Bot. Gaz. 67: 60-61). His remarks are as follows: "There are before me several specimens collected at Great Slave Lake, Mackenzie, which, in my opinion, are most closely related to var. *acutifolia*, but at least some of them seem to represent a very villous form of it, for which I propose the name: *S. GLAUCA* var. *ACUTIFOLIA* f. ***poliophylla, forma nov. — A typo nonnisi differre videtur ramis annotinis densius villosolano-lanuginosis etiam vetustioribus tomento lanuginoso pl.m. obtectis, foliis superne pl.m. laxe adpresse sericeo-lanuginosis subtus villo densissimo molli pl.m. adpresso albo vestitis. The type is Great Slave Lake, Fort Rae, July 28, 1901, *E. A.* and *A. E. Preble* (no. 139, fr.; W.; folia inferiora elliptica vel oblongo-elliptica, utrinque acuta, superiora magis ovato-elliptica apice acutiora, maxima ad 5: 2.2 cm. magna; amenta fructifera pedunculo foliato ad 3 cm. longo excluso ad 5: 1.3 cm. magna; fructus e basi rhomboideo ovoideo-conici, ad 9 mm. longi pedicello ad 1.5 mm. longo glandulam subduplo superante excluso)." Schneider cited some other Preble specimens as intermediate between this form and typical var. *acutifolia*: Ft. Resolution, no. 141 and no. 194, Ft. Good Hope, Mackenzie R., nos. 330 and 332. The writer has not seen the Preble specimens, but there is a good photograph of the type of f. *poliophylla* in the Herbarium of the Arnold Arboretum. It is matched very well by the writer's no. 503, collected at Yellowknife Bay, Aug. 22, 1927. Other material collected in 1932 near Sand Pt., Lake Athabaska, shows the same tendency to be extremely villous on leaves and twigs (nos. 4508, 4597), and is evidently closely related to the Great Slave Lake plants. The same is true of a specimen collected at the eastern end of Lake Athabaska in 1935 by R. S. Campbell, no. 132395(O). With the more abundant material now at hand, therefore, the form seems worthy of being considered as a variety having a distinct geographic affinity in the central part of the Mackenzie basin.

***Salix Mackenzieana* Barratt.** — See Jour. Arn. Arb. 2: 190 (1921). — Occasional on gravel bars and local river flood plain deposits

along the major streams, northward to the Mackenzie (*Richardson*, G), but not known in the pre-Cambrian country. — Island in Slave R. below Grande Detour, *Harper*, no. 99026(O); Great Slave L.? *Richardson* (G).

Salix lutea Nutt. — Abundant on the upper parts of local flood plain deposits in the great river lowlands northward at least to the Slave River. — Along the Quatre Fourches R., in the lower Peace delta, nos. 555, 558; upper Slave R. lowland, no. 554; lower Slave R., no. 557.

Salix Turnorii, sp. nov.

PLATE 193¹

Frutex 1.8–3 m. altus, habitu erecto stricto; cortex pallide cinerascens, ramulis novellis rubris exceptis; ramuli novelli tenuiter pubescentes, ceterum rami glabri; folia matura lanceolata, elliptica, vel oblanceolata, basi acuta vel leviter rotundata, apice acuta ad acuminata, 2–3.5 cm. longa (pleraque 2.5–3 cm.) 6–10 mm. lata (pleraque 7–8 mm.), utrinque pallide viridia, subtus paulo pallidiora, modice reticulata, paulo firma et coriacea, subtiliter et aequaliter glanduloso-serrata, glandulis rubescentibus leviter incurvis, novella subtus sericea mox glabrescentia; petioli 2–5 mm. longi, glabri novellis exceptis, rubri; stipulae 1–5 mm. longae, ovatae, obtusae ad acutae, glanduloso-serratae, colore foliis similes, persistentes. Amenta feminea 1–3 cm. longa, 1–1.5 cm. lata, pedunculo brevi foliato suffulta; capsula circa 5 mm. longa, rostrata, glabra, rubescenti-brunnea, pedicellis glabris rubescenti-brunneis circa 2–3 mm. longis suffulta; styli 0.5 mm. longi, indivisi, stigmatibus subcapitatis; bracteae anguste lineares vel lineari-lanceolatae, pedicello triente breviores, glabrae vel paulo pubescentes, rubescenti-brunneae, persistentes; glandula truncata, lanceolata ad linearis, circa 0.5 mm. longa; rachis cinereo-pubescentis.

Among inland shifting sand dunes south of William Point, south shore of Lake Athabaska, Sask., Aug. 16, 1935, no. 6885 (Type, A). Another number (6908) collected from the same dune region, but about 4 miles west, on Aug. 20, 1935, is identical with the type number.

This willow seems most closely related to *S. cordata* or *S. lutea*, in the section CORDATAE of Barratt. Its combination of small, regularly glandular-serrate leaves, bright red new twigs, gray-green older twigs and bark, and its striking upright, rather narrowly pyramidal habit clearly distinguish it from these species or their close relatives. In leaf and twig characters it suggests somewhat certain forms of *S. Goodingii* Ball,

¹PLATE 193. *Salix Turnorii* Raup. Details are part of type number collected on shifting dunes about 5 miles south of William Pt., Lake Athabaska, no. 6885; details of aments $\times 2$; habit photo taken on the same dune area, just east of Ennuyseuse Creek, August 20, 1935.

in the section *NIGRAE*, or forms of *S. amygdaloides* Andersson, in the *TRIANDRAE*, but its persistent reddish-brown scales separate it from either of these groups. It is named for Philip Turnor, a pioneer geographer who, while in the employ of the Hudson's Bay Company in 1791, made a surprisingly comprehensive and accurate map of Lake Athabaska and connecting waterways.

Salix Farrae Ball. — See Contr. U. S. Nat. Herb. **22**: 321 (1921) and Univ. Calif. Pub. in Bot. **17**: 406-9 (1934). — Apparently rare in our region, and known only in the southwestern part of the Wood Buffalo Park where it grows in muskeg thickets in the Caribou Mts.

Salix myrtillofolia Anders. — See Jour. Arn. Arb. **2**: 193 (1921). — An abundant species in timbered muskegs northward to Great Bear Lake (*Richardson*, G, N) and the Mackenzie (*Preble*). Tyrrell noted it on Artillery Lake just at the edge of the timber. — Clearwater R., *J. M. Macoun*, no. 18854(O) (N. E.). Lake Athabaska: near Sand Pt., no. 4637; Camsell Portage, nos. 6176, 6177, 6198, 6199; Charlot Pt., no. 6298. Upper Slave R. lowland, no. 516; Tazin R., N. of L. Athabaska, *Harper*, no. 99024(O). Great Slave L.: Caribou Isl., *Seton & Preble*, no. 78306(O) (N. E.); Taltheilei Narrows, no. 519; Fairchild Pt., nos. 517, 518, 520. E. A. Preble cited material in his list from Resolution, but this has not been seen by the writer.

Salix pseudomonticola Ball. — See Contr. U. S. Nat. Herb. **22**: 321 (1921) and Jour. Arn. Arb. **3**: 73 (1921). — Apparently occasional in the fringe of timber along pond and lake shores in the Wood Buffalo Park and southwestward. Most of the material collected thus far is scanty, and the species needs further study in our region. — Athabaska Landing, *Ball*, no. 2362(O).

Salix pyrifolia Anders. — *S. balsamifera* Barratt. — See Jour. Arn. Arb. **1**: 168 (1920). — Occasional at muskeg and slough margins northward to the Lake Athabaska district and the Wood Buffalo Park. It appears to be commonest in the pre-Cambrian country. — Lower Athabaska (Elk) R., *Kennicott* (N). Lake Athabaska: Shelter Pt., nos. 573, 574, 575, 4456, 4459; near Sand Pt., no. 4596; Camsell Portage, no. 6183; 5 mi. E. of Poplar Pt., nos. 6664, 6677; along William R. near its mouth, no. 6874; 2 mi. W. of Ennuyeuse Cr., no. 6945. Hill Island L., *Harper*, no. 99021(O).

Salix alaxensis (Anders.) Cov. — See Jour. Arn. Arb. **1**: 223 (1920), Contr. Arn. Arb. **6**: 147-9 (1934). — A northwestern arctic and alpine species which reaches our region on Great Slave Lake, where it inhabits sandy and gravelly shores. — Great Slave L.: Caribou Isl., *Seton & Preble*, no. 78302(O) (N. E.); Taltheilei Narrows, no. 502;

Fairchild Pt., nos. 500, 501, 504; Ft. Reliance, no. 499; N. W. shore, Bedford (O).

Salix silicicola, sp. nov.

PLATE 194¹

Frutex erectus ramis patulis, 1.2–3 m. altus; cortex rubescenti-brunneus; ramuli dense albo-pilosi vel albo-tomentosi, tomento diu persistente; folia matura integerrima, late elliptica ad obovata, pleraque obovata, basi rotundata vel leviter cuneata, apice pleraque obtusa vel rotundata et leviter mucronata, sed aliquando acuta, 3–6 cm. longa, 2–3.5 cm. lata, conspicue reticulata, utrinque lana crassa alba sericante dense vestita, supra cinerea ad pallide viridia, infra alba; petioli 2–10 mm. longi, albo-piloso-tomentosi, aliquando alati; stipulae late ovatae ad lanceolatae, obtusae vel acutae, 3–7 mm. longae, aliquando tenuiter glanduloso-serratae, piloso-tomentosae ut petioli et folia, persistentes. Amenta feminea sessilia, 2–7 cm. longa, dense florifera, matura circa 1 cm. lata; capsula pilosa, circa 6 mm. longa, 2–3 mm. lata, sessilis vel pedicello quam 1 mm. brevior; bractee late ovatae, 2–2.3 mm. longae, basi rubro-fulvae apicem versus nigrescentes, obtusae vel acutae, pilis albis quam bractee 2-plo vel ultra longioribus; styli 2–2.5 mm. longi, apice ad quartam partem bifidi, stigmatibus linearibus; glandula unica ventralis oblonga, rubro-fulva, 0.5–1 mm. longa, 0.2–0.3 mm. lata, indivisa. — Sandy beach ridges just east Wolverine Pt., south shore of Lake Athabaska, Sask., July 28, 1935, no. 6704 (Type, A). Two other numbers collected on the south side of Lake Athabaska match the type material. No. 6907 was secured on the shifting dunes south of William Pt. on August 20, and no. 6952 was collected on the sandy shore of the lake just west of Ennuyeuse Cr., on Aug. 22.

Salix silicicola is one of the most attractive willows of the Mackenzie basin, and is made conspicuous against the dark greens of the conifers by its nearly white leaves and twigs. It clearly belongs to the section *Chrysanthae* of Koch, which contains also *S. Hookeriana*, *S. laurentiana*, *S. alaxensis*, and *S. Barrattiana*. Of these it is most nearly related to the typical forms of *S. alaxensis*, which it resembles in habit, in the general shape of its leaves and aments, and in its long styles. It differs notably from *S. alaxensis*, however, in having stipules shorter (up to 7 mm. long as against 22 mm.) broadly ovate to lanceolate rather than linear-lanceolate to filiform, and in having a persistent, heavy, hirsute-

¹PLATE 194. *Salix silicicola* Raup. Details are part of type number collected on sandy beach ridges just east of Wolverine Pt., Lake Athabaska, no. 6704; habit photo taken among shifting sand dunes just east of Ennuyeuse Creek, August 20, 1935.

tomentose covering on both sides of the leaves instead of having the leaves glabrate or quite glabrous and bright green above. Further, its leaves are consistently broader than those of *S. alaxensis*, as well as more strongly obovate and obtuse.

Salix candida Flüggé. — Occasional or common in muskeg thickets northward in the Paleozoic and younger country at least to Great Slave Lake. Noted in Fl. Bor.-Am. as occurring "throughout the woody country," but the writer has seen no material from north of those cited below. — Slave R., *Richardson* (O); low island 3 mi. W. of Rocher R., Great Slave L., *Harper*, no. 99014(O); Great Slave L., *Seton & Preble*, no. 78307(O) (N. E.).

Salix Bebbiana Sarg. — *S. rostrata* Richards., not Thuill. — This is probably the most abundant willow in our region, and is known far northward to Great Bear Lake and the lower Mackenzie (*Richardson*, N; *McConnell*, O). It commonly grows to a height of 15 or 20 feet, and is the most important constituent of the small tree and shrub layer in nearly all of the woodlands of the Wood Buffalo Park and southward. It is most common in young river bottom timber and upland aspen woods. Eastward in the pre-Cambrian country it commonly grows on sandy and gravelly lake shores. Both Rydberg and Schneider regarded *Richardson* specimens cited below, and originally labeled *S. rostrata*, as part of the type material of the species. Schneider has kept up var. *perrostrata* (*S. perrostrata* Rydb.) for some of the glabrescent leaved forms of the species, and has referred some of the following specimens to it tentatively. The present writer, however, has been unable to distinguish the variety satisfactorily among Mackenzie basin material. — Lac la Biche, nos. 6009, 6010; Athabaska Landing, *Ball*, no. 2365(O); McMurray, *Dutilly*, no. 116(G); along the Athabaska R., below McKay, no. 6005; Calumet, Athabaska R., nos. 543, 544; along the Firebag R. near its mouth, nos. 6048, 6049. Lake Athabaska: Sand Pt., no. 4657; Charlot Pt., nos. 6145, 6146, 6262; N. shore, *J. W. Tyrrell*, no. 1766(O); 5 mi. E. of Poplar Pt., no. 6683; near Wolverine Pt., no. 6716. Delta of Peace R. (Quatre Fourches R.), nos. 540, 542; E. shore of L. Mamawi, nos. 2107, 2108; upper Slave R. lowland, nos. 539, 2111; Ft. Smith, nos. 538, 2118; and *Seton & Preble*, nos. 78311, 78312, 78309, 78310(O); Slave R., *Kennicott* (N). Tazin R. above Great Falls, *Harper*, no. 99031(O); junction of Telon and Tazin R.'s, *Harper*, no. 99028(O); lake on Tazin R., *Harper*, no. 99023(O). Fort Franklin and Portage la Loche (Methye Portage), *Richardson* (N) (apparently *S. fusca* of Fl. Bor.-Am.); between Simpson and Chipewyan, *Richardson* (O) (*C. rostrata* in Fl. Bor.-Am.); between Cumberland

House and Ft. Franklin, *Richardson* (G, N) (*C. rostrata* in Fl. Bor.-Am.). Great Slave L.: Resolution, *Dutilly*, no. 108(G); near Caribou Isl., *Seton & Preble*, no. 78308(O); base of Maufelly Pt., no. 536; Ft. Reliance, no. 545; Yellowknife Bay, no. 537; N. W. shore, *Bedford* (O) (doubtful fragment).

Salix pedicellaris Pursh var. ***hypoglauca*** Fern. — See Jour. Arn. Arb. 2: 81-2 (1920). — Occasional in shrubby muskegs northward to Great Bear Lake (*Richardson*, N). On the south side of Lake Athabaska it is common at the margins of sandy ponds. — Professor Fernald has regarded typical *S. pedicellaris* Pursh as a comparatively rare plant with leaves green on both surfaces (Rhod. 11: 161), an opinion not held by Schneider who grouped all American material with the typical species. Pursh's type is not available, but Schneider regarded the notes on leaf character in its description as inconclusive since it was collected very early in the season (April, in the Catskill Mts.). However, Pursh states also that the species flowered later in a European garden, so that he may well have been familiar with its mature leaves. — Lake Athabaska: near Sand Pt., no. 4507-a; 5 mi. E. of Poplar Pt., no. 6685; about 5 mi. S. E. of Wolverine Pt., no. 6811; 2 mi. W. of Ennuyeuse Cr., no. 6975.

Salix pedicellaris Pursh var. ***tenuescens*** Fern. — See Rhod. 11: 162 (1909). — Apparently rare in the Mackenzie basin, and known from a single collection in an upland muskeg thicket in the Wood Buffalo Park.

Salix athabascensis Raup. — See Rhod. 32: 111 (1930). — Known thus far only from its type locality, an upland muskeg thicket in the Wood Buffalo Park.

Salix petiolaris Sm. — Common at the margins of sloughs and semi-open prairies northward in the Paleozoic and younger country to the Wood Buffalo Park. Tyrrell noted it on the north shore of Lake Athabaska, but no specimen is available. — East shore of L. Mamawi, nos. 2123, 2124, 4405; upper Slave R. lowland, nos. 567, 569; Ft. Smith, no. 568.

Salix Scouleriana Barratt. — See Jour. Arn. Arb. 2: 6-13 (1920). — A common willow about Lake Athabaska, but apparently unknown elsewhere in the Mackenzie basin east of the mountains. It usually grows on gravelly or sandy lake beaches, or on rather dry upland sand plains. Certain specimens collected at Charlot Pt. in 1935 (nos. 6151, 6154, 6155, 6161) seem to approach *S. planifolia* in leaf characters. — Lake Athabaska: Shelter Pt., nos. 525, 526, 527, 4450; Sand Pt., no. 4468; Charlot Pt., nos. 6150, 6151, 6154, 6155, 6161, 6263;

near base of Cornwall Bay, no. 6599; 5 mi. E. of Poplar Pt., no. 6663; about 4 mi. S. E. of Wolverine Pt., nos. 6750, 6781; shifting sand dunes S. of William Pt., no. 6886 (forma *poikila* Schn.).

Salix planifolia Pursh. — *S. chlorophylla* Anders. — Abundant at slough and prairie margins, and on local river flood plains throughout most of the wooded country northward to Great Slave Lake, and known from Great Bear Lake (*Richardson*, N) and the lower Mackenzie (*Preble*). It is common in the pre-Cambrian country about Lake Athabaska, but has not been collected on the eastern arm of Great Slave Lake. — Grand Rapids, Athabaska R., *Harper*, no. 99017(O); Calumet, Athabaska R., no. 508; along Firebag R. near its mouth, nos. 6022, 6027, 6028. Lake Athabaska: Shelter Pt., nos. 506, 507, 509, 510, 4458, 4459-a; Sand Pt. and vicinity, nos. 4539, 4580, 4658; near Fishing R., no. 6077; Charlot Pt., nos. 6147, 6148; Camsell Portage, nos. 6179, 6180, 6193; near base of Cornwall Bay, nos. 6489, 6631; 5 mi. E. of Poplar Pt., no. 6686; near Wolverine Pt., no. 6794; along William R. near its mouth, no. 6875; about 2 mi. W. of Ennuyeuse Cr., nos. 6944, 6949. East shore of L. Mamawi, nos. 2144, 2145, 2146; lower delta of Peace R., no. 515; upper Slave R. lowland, nos. 513, 2148. Great Slave L.: Resolution, *Preble*, no. 143(W) (N. E.); near Stoney Isl., *Seton & Preble*, no. 78299(O) (N. E.); about 15 mi. E. of Moraine Pt., *Bedford* (O) (doubtful fragment).

Salix Nelsonii Ball. — This species may prove to be only a variety or form of *S. planifolia*, as strongly suggested by Schneider (Jour. Arn. Arb. 1. 80-1). It is occasional at upland slough margins west of the upper Slave River.

Salix subcoerulea Piper. — A cordilleran species known only in the southern and southwestern parts of the Mackenzie basin. — Athabaska Landing, *Ball*, no. 2364(O).

Salix arbusculoides Anders. — See Jour. Arn. Arb. 2: 84 (1920). — A common willow of muskeg and slough margins throughout the Paleozoic and younger country. Eastward in the pre-Cambrian it is usually found on damp sandy or rocky shores, and on river flood plains it appears at the margin of the high timber. — Athabaska Landing, *Ball*, no. 116491(O) (N. E.); along the Firebag R. near its mouth, no. 6032. Lake Athabaska: Sand Pt., no. 4509; Charlot Pt., nos. 6152, 6153, 6159. Upper Slave R. lowland, nos. 550, 2097; Ft. Smith, no. 2096; lower Slave R., *Harper*, no. 99027(O). Great Slave L.: Resolution, *Preble*, no. 151(W) (N. E.); Maufelly Pt., no. 543; Fairchild Pt., nos. 529, 549, 551, 552, 553; N. W. shore, *Bedford* (O); Loon Isl., *Preble*, nos. 133, 134 (W) (N. E.).

MYRICACEAE

Myrica Gale L. — Common in the pre-Cambrian country northward to Great Slave Lake, and noted by Richardson and Preble at Ft. Norman and Great Bear Lake, respectively. It appears to be quite rare west of the Slave River. It inhabits swamps and sandy lake shores. — Lake Athabaska: Shelter Pt., nos. 629, 632, 633, 4444; Sand Pt., no. 4652; Camsell Portage, no. 6191; mouth of Charlot R., no. 6310; N. shore, *J. W. Tyrrell*, no. 24056(O); mouth of Archibald R., no. 6769; bank of William R. near its mouth, no. 6872. Great Slave L.: Taltheilei Narrows, no. 627; mouth of Mountain R., no. 631; Fairchild Pt., nos. 628, 630, 635, 636; Yellowknife Bay, no. 634; N. W. shore, *Bedford* (O).

(*To be continued*)



DESCHAMPSIA MACKENZIEANA Raup



SALIX BRACHYCARPA var. *PSAMMOPHILA* Raup



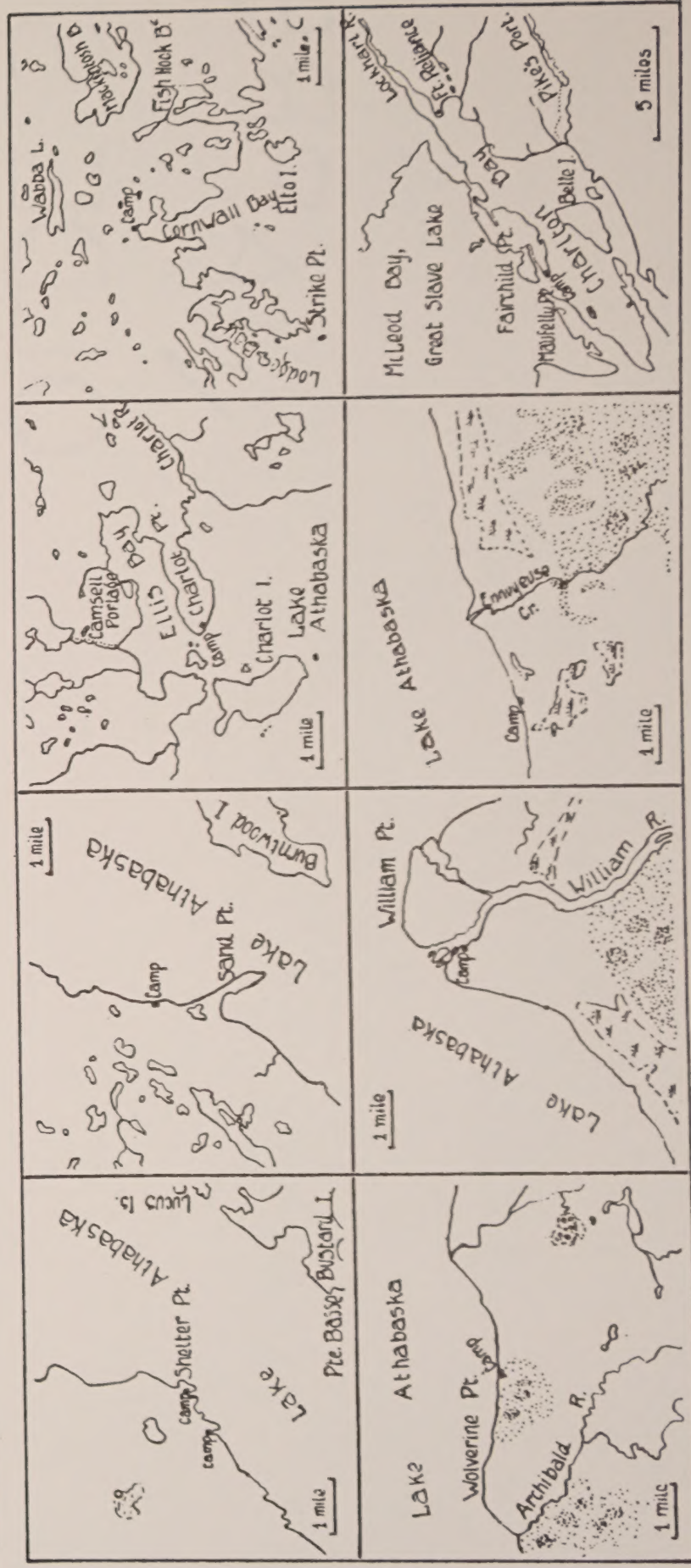
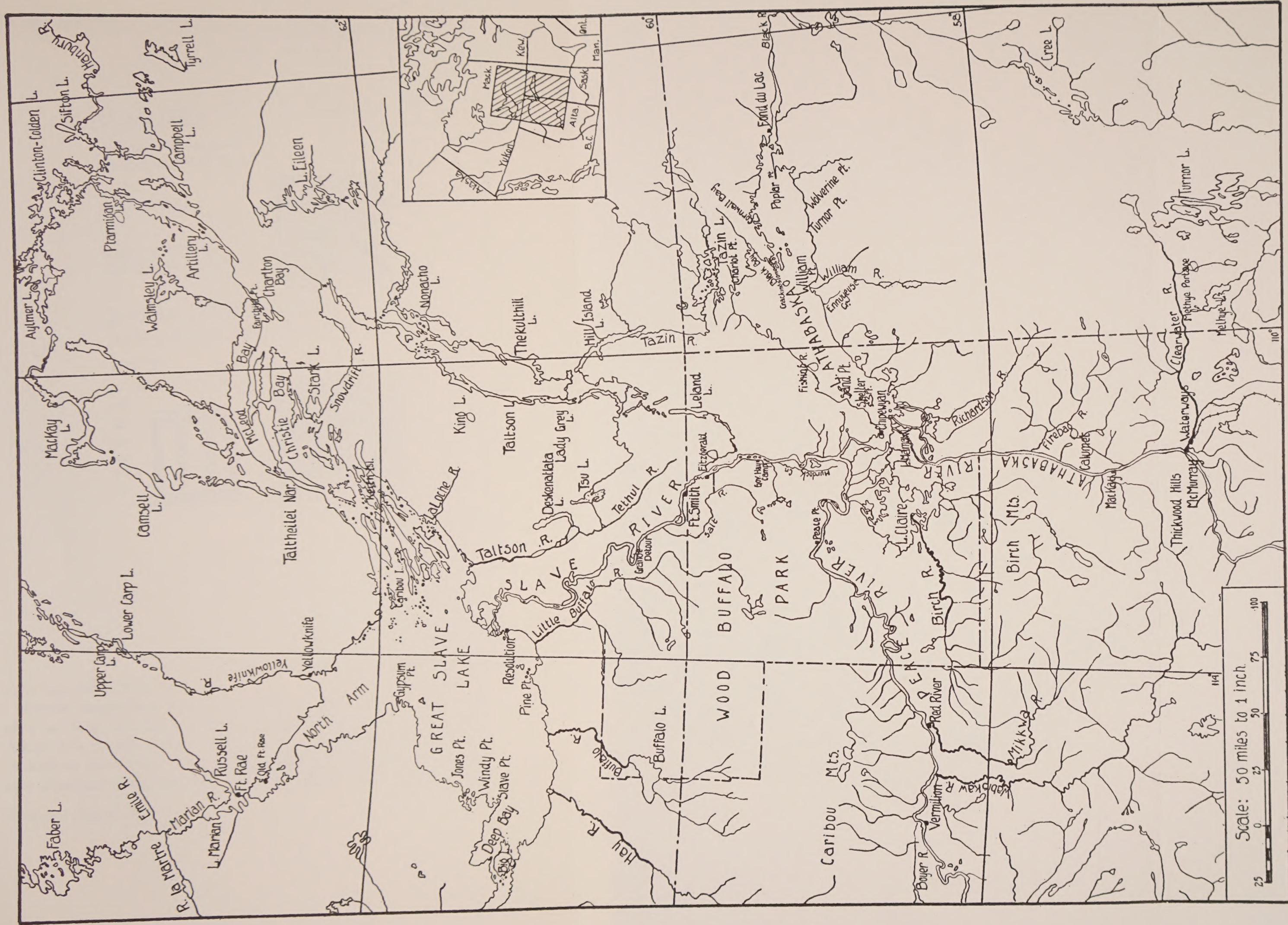
SALIX TYRELLII Raup



SALIX TURNORII Raup



SALIX SILICICOLA Raup



MAP OF ATHABASCA — GREAT SLAVE LAKE REGION, WITH DETAILS OF COLLECTION LOCALITIES.

